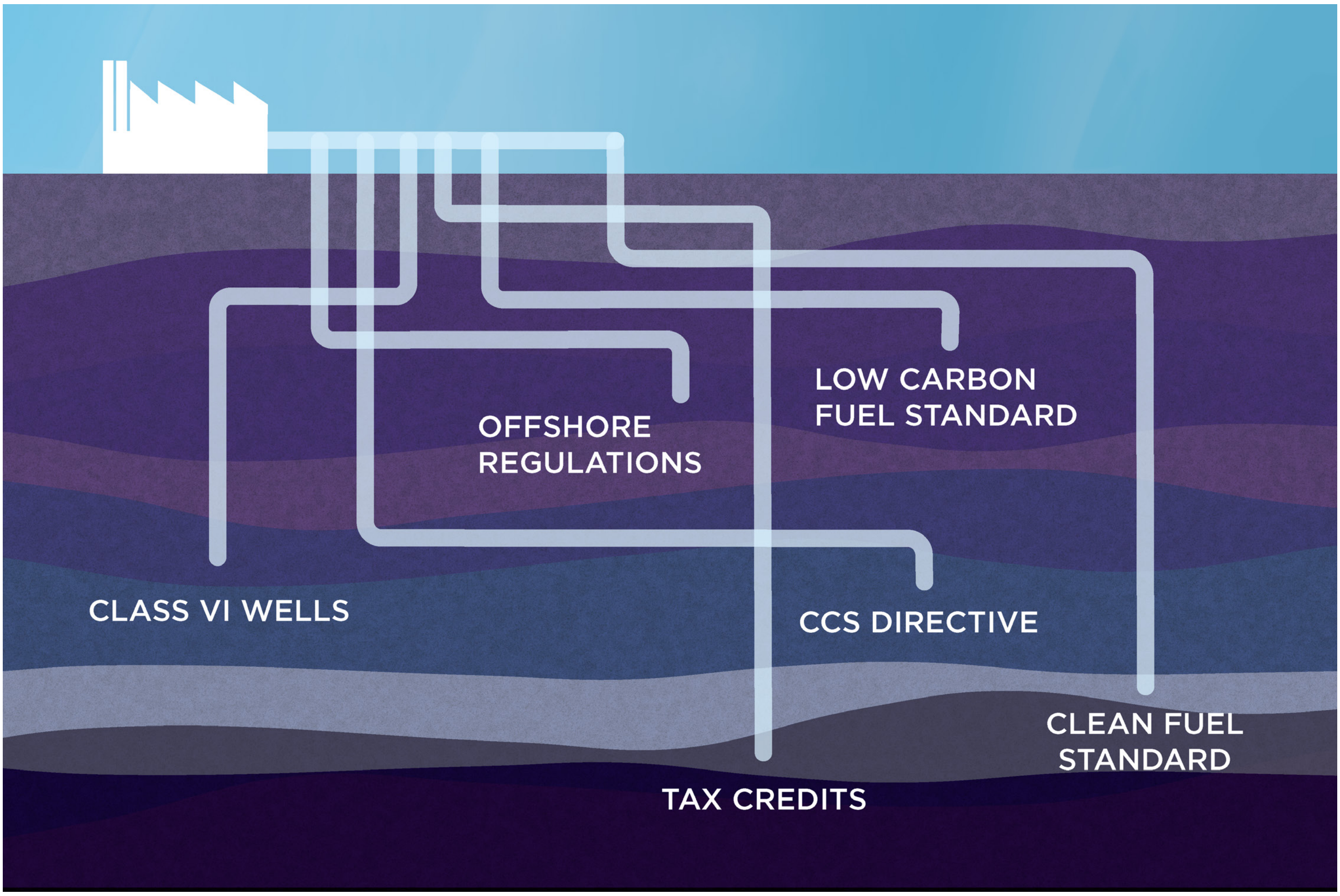

Survey of CO_2 Storage Regulations

April 2019

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Survey of CO2 Storage Regulations

Final Version

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Acronyms and Abbreviations

AGD	Acid Gas Disposal
AOR	Area of Review
BC LCFS	British Columbia Low Carbon Fuel Standard
BEIS	Department of Business, Energy and Industrial Strategy (UK)
CA LCFS	California Low Carbon Fuel Standard
CARB	California Air Resources Board
CCP	CO_2 Capture Project
CCS	Carbon capture and storage
CCUS	Carbon capture utilisation and storage
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
DoE	Department of Energy (USA)
EIA	Environmental Impact Assessment
EOR	Enhanced oil recovery
EPA	Environmental Protection Agency (USA)
EPZ	Emergency Planning Zone
EU ETS	European Union Emissions Trading System
EUAs	European Union Allowances under the EU ETS
GCCSI	Global Carbon Capture and Storage Institute
GHG	Greenhouse Gas
GHGRP	Greenhouse Gas Reporting Program (USA)
GS	Geological Sequestration
IMO	International Maritime Organisation
ISO	International Organisation for Standardisation
MIT	Mechanical Integrity Tests
MMV	Measurement, Monitoring and Verification
MRV	Monitoring, Reporting and Verification
Mt	Mega tonne (one million metric tonnes)
OPGGS	Offshore Petroleum and Greenhouse Gas Storage Act (Australia)
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
PCSF	Post-closure Stewardship Fund (Alberta)
PISC	Post-injection Site Care
RFA	Regulatory Framework Assessment (Alberta)
SDWA	Safe Drinking Water Act (USA)
UIC	Underground Injection Control (USA)
UNFCCC	United Nations Framework Convention on Climate Change
US DOE	US Department of Energy
US EPA	United States Environmental Protection Agency
USDW	Underground Sources of Drinking Water (USA)

EXECUTIVE SUMMARY

There is now a wide range of regulations that govern CO_2 storage projects across the globe. This report focuses on rules and regulations for CO_2 storage projects with an emphasis on key learnings, potential gaps and main findings to support the viability of CO_2 storage projects both onshore and offshore in a practical and commercial context. The research is limited to CO_2 injection and long-term storage.

Regulators are aiming to promote transparency and generally considering public comments from key stakeholders when developing regulations. Although many of these regulations have yet to be rigorously tested due to a low level of deployment of actual CCS projects on the ground, reviews of regulations have been carried out using hypothetical projects (Victoria, Australia) or recommendations from technical panels (Alberta CCS).

Regulations for CCS have been shaped by multiple regulators, operators and key stakeholder groups. We looked at regulations for permitting and for qualifying CO_2 storage projects for incentives. These regulations are not consistent across the globe, with various disparities in the treatment of long-term liability and post-injection monitoring requirements. Despite this, there are some areas such as the need for proof of financial ability to cover potential liabilities and public engagement which are, on the whole, being approached in a similar way.

In general, there has been a growth in CCS policy confidence. This can be seen in the development of new regulatory frameworks; in particular, such as tax incentives provided by the Internal Revenue Service's 45Q provisions in the United States. This is also reflected in the growing ambition of certain countries such as the UK, who have created the CCS Council and CCUS Cost Challenge Taskforce with the aim to make CCUS economically feasible.

The GCCSI legal and regulatory indicator ranks only five countries as having legal and regulatory models which are sophisticated enough to address novel aspects of the CCS process: Australia, Canada, Denmark, the UK and the USA. This shows there is still a considerable amount of development required in many countries, such as Japan and Indonesia, as highlighted in this report.

MAIN FINDINGS

This report looks at selected recent developments in regulations for CO_2 storage projects with particular emphasis on any key developments, outstanding issues or gaps that might help or hinder commercial success of CO_2 Capture and Storage (CCS).

There is now a wide range of regulations that govern CO_2 storage projects across the globe. These regulations have been influenced by multiple regulators, operators and key stakeholder groups. The report includes regulations for permitting and for qualifying CO_2 storage projects for incentives. The focus is on rules and regulations for CO_2 storage projects relevant to the oil & gas as well as other industries, with an emphasis on key learnings, potential gaps and main findings to support the viability of CO_2 storage projects both onshore and offshore in a practical and commercial context. The research is limited to CO_2 injection and long-term storage.

CCS Incentives and Funding

Significant developments have recently occurred in relation to incentives and funding for CO_2 storage projects. Most notable are developments in California, the European Union and at federal level in the USA.

California

From January 1st 2019, the CCS Protocol comes into force as part of the latest amendments to the California Low Carbon Fuel Standard (LCFS). The California Air Resources Board (CARB) aimed for the CCS Protocol to be the most robust regulation released to date, for the benefit of environmental integrity but also reputation of the technology. If the first CCS project fails, it could damage the integrity of CCS, which CARB acknowledged is potentially very important for climate change mitigation. CARB indicated that California is *"willing to pay a premium"*[1] for complying with the LCFS protocol, compared with the highest value of credits of any program, which currently range from $180-200/tCO_2e (referring to the market price of California LCFS credits, awarded for sequestered CO_2 by qualified CA LCFS CCS projects).

As part of the CA LCFS CCS Protocol, monitoring to ensure the stability of the CO_2 plume and track leakage, if relevant, must occur for 100 years post injection. Whilst the plume is stabilising, significantly more stringent monitoring is required. Once the plume is stable, the wells can be plugged and abandoned, with monitoring reduced to a lower level, which remains in force at this lower level for the rest of the 100-year period. The CA LCFS CCS Protocol has a buffer account, which is an assurance pool of credits that all projects contribute to. The amount of credits paid into the buffer account depends on the project's risk rating which is dependent on the project. The operator is only liable to pay back credits for the first 50 years if leakage occurs. Prior to 50 years post injection, credits from the buffer account up to and including the project's total contribution can count towards leakage-related credit invalidation. If the leakage exceeds this contribution to the buffer account, the project operator must retire any outstanding credits. After 50 years post-injection, the CCS project operator is no longer responsible for credits found to be invalid due to leakage. Other credits from the buffer account can be used to cover this leakage. Thus, the burden on CCS project proponents under the CA LCFS after 50 years is only lower level monitoring, not liability for credits if there is post-closure leakage after 50 years.

European Union

As part of the latest amendments to the Directive for the EU Emissions Trading System, which occurred in March 2018, the European Commission has developed an Innovation Fund that will launch in 2021. 450 million EU ETS Allowances have been put aside to support low-carbon technologies including carbon capture and utilisation as well as products substituting carbon intensive

[1] Compared to the value of incentives of the California cap and trade system

ones. The fund is also available to help stimulate the construction and operation of CCS projects as well as innovative renewable energy and energy storage technologies. Projects in all EU member states including small-scale projects are eligible for the new fund.

USA

In the USA, the FUTURE Act provides additional financial certainty for private investors and developers of carbon capture projects by lifting the current cap on available 45Q US tax credits and increasing their value for each ton of CO_2 captured and safely stored or put to beneficial use. The tax credit seeks to incentivise private investment in commercial deployment of technologies to capture carbon dioxide (CO_2) from power plants and industrial facilities for enhanced oil recovery (CO_2-EOR), other forms of geologic storage and for beneficial uses of CO_2. The incentive is performance-based, so only projects that successfully capture and store CO_2 can claim the credit. The updates to the tax credit include:

- 10-year ramp up to $35 per ton for CO_2 stored geologically through EOR.
- 10-year ramp up to $35 per ton for other beneficial use such as converting carbon emissions into fuels, chemicals, or useful products like cement.
- 10-year ramp up to $50 per ton for CO_2 stored in other geologic formations and not used in CO_2-EOR or for other purposes.
- No cap on total credits that can be claimed under 45Q.
- Eligible projects that begin construction within seven years of the enactment of the FUTURE Act (i.e., before January 1, 2024) can claim the credit for up to 12 years after the carbon capture equipment is placed in service.

Detailed Comparison between Key Regulations

As part of the research, a detailed comparison was undertaken of five different regulatory frameworks that best address the key regulatory issues (see Table 9.1 for full details):

- EPA UIC Class VI Well Permits
- California LCFS
- Alberta CCS Regulatory Framework Assessment recommendations
- EU CCS Directive
- Australian Offshore Petroleum Amendment

The report has a wide geographical coverage, including regulations from the USA, Canada, the EU, the UK, Netherlands, Norway, Indonesia, Japan and Australia.

Post-Injection Site Care (PISC) and Site Closure

The period for post-injection site care (PISC) varies from a maximum of 100 years monitoring for the CA LCFS to a minimum of 15 years in the Australian Offshore Petroleum Amendment. This is certainly a key area where there is disparity between regulations, at the same time that there is also flexibility in some regulations on the length of PISC. The extent to which the variation in PISC regulations may be a barrier to CCS project viability depends on the overall context of each regulatory regime. Project developers who operate globally will certainly need to take into account that such wide variations in the CCS regulatory regimes do exist.

Financial Requirements

Mandatory regulations such as the EU CCS Directive or the US EPA Underground Injection Control (UIC) Class VI regulations require proof of financial resources to cover any obligations relating to corrective measures or leakages. Proof of financial ability to cover potential liabilities is fairly standard across various CCS regulations, except the CA LCFS, where this is considered out of scope because CCS project operators apply for CA LCFS credits as a financial incentive rather than regulatory compliance.

Long Term Liability

There is considerable disparity between regulations in relation to long-term liability. For the US EPA UIC Class VI well permits, site closure does not eliminate responsibility or liability and the EPA cannot transfer this liability between entities. For the CA LCFS the operator is liable for leakage the first 50 years (to buy credits to offset leakage), after which any liability is paid from the CA LCFS buffer pool of credits instead.

Liability is transferred to the Member state authority after at least 20 years after site closure in the EU CCS Directive, unless there are concerns over permanence of the CO_2. Liability is also transferred back to the Commonwealth for the Australian Offshore Petroleum Amendment, the time at which this occurs depends on when a closure assurance period occurs, which is after at least 20 years. In summary, not all regulations allow a transfer of liability back to the state or relevant authority, and those which do have differing time frames for when this can occur.

Liability for Leakage and Environmental Damage

In all regulations, there is a level of financial liability for environmental damage or leakage of CO_2. How this is paid depends if there is a credit system in place; for example, surrender of emission trading allowances for the EU CCS Directive. The Alberta RFA recommends creation of a post closure stewardship fund which all projects contribute to, which has a similar role to the buffer pool which has been established in the CCS Protocol of the CA LCFS. The remaining regulations mainly require the operators to correct the physical damage and pay any fines.

Public Engagement

In general, the regulators all make aims to be transparent and engage the public and other key stakeholders. The US EPA is required to respond to comments made on UIC Class VI permit applications; applicants must respond to comments on applications to qualify for the CA LCFS; and the Commonwealth Minister will consider comments made from applications in Australia. In the EU CCS Directive, provisions must be put into place in member states to engage the public, in addition to public access to the EU Commission's reviews of all CCS permit applications within member states.

Thresholds

Some regulations apply only to projects meeting certain requirements; for example, the EU CCS Directive and the Australian Offshore Petroleum Amendment do not apply to projects storing less than 100 kilotonnes of CO_2. The other regulations do not have any thresholds; all projects which are undertaking geologic storage of CO_2 must have a valid permit.

Monitoring and Reporting

Monitoring and reporting plans and requirements vary considerably between regulations. Most regulators require an annual report but others have more demanding requirements. For example, the CA LFCS requires semi-annual reporting from CCS projects, informing CARB every quarter of details relating to quantities of fuels sold for the CA LCFS. In general, most regulators require a monitoring or environmental plan to be submitted with the application which will include how the plume is monitored, what technologies are used, how this will be recorded and verified if appropriate, in addition to any other monitoring of the surface, water sources or subsurface with duration of the monitoring period varying between regulations.

Pore Space Access

Addressing concerns relating to accessing pore space is considered out of scope for both the EPA UIC Class VI well permits and the CA LCFS. This is because both programs see pore space access as the CCS project developers commercial responsibility; i.e., if there is no pore space access negotiated by the developer, then there is no CCS project for the US regulators to review.

The EU CCS Directive requires member states to ensure measures are taken to allow operators to obtain pore space access. In Australia, operators must apply for access to acreage through the Commonwealth Minister for offshore storage.

In many cases, access to pore space and duration of that access for specific projects may be seen by regulators to be a commercial siting issue for project developers governed by local laws for mineral rights or sub-surface activities, and not a permitting issue *per se*.

Flexibility

The CA LCFS CCS Protocol is a very prescriptive regulation. CARB said the philosophy for fixed regulatory requirements was rewarded with the highest value of credits of any current program which are at present US$180-200/tonne. The value of sequestered CO_2 emissions under the LCFS is a proportion of the equivalent number of LCFS credits minus loses from breakthrough gases and operational emissions. CARB felt that rewarding CCS project developers with this level of benefit is in line with regulations to ensure certainty for long-term underground retention of CO_2.

Many other regulations do allow some form of discretion in certain permit conditions by a senior regulator such as the EPA Program Director or the Commonwealth Minister depending on project-specific circumstances.

Other Variations

There are some other variations between regulations worth noting. In the USA, states can apply for primacy to regulate the UIC permits themselves instead of the EPA which could lead to inconsistency between implementation of the regulation between states, but could also streamline or speed up CCS project applications in some states compared to others.

In contrast, to maintain consistency in the EU CCS Directive, the EU Commission intends to review all CCS project applications across all member states.

Finally, in line with the stringent nature of the CA LCFS regulations, operators must have their projects verified every year in order to assure the CO_2 is being stored safely.

UIC Class VI and Class II Comparison

The US EPA UIC Class VI well regulations for CCS are quite extensive, much more so than the UIC Class II regulations for EOR projects. The main additional requirements for Class VI permit regulations over Class II are greater financial responsibility, continuous monitoring during operations, more rigorous testing, and 50 years PISC. This includes:

- Class II requires financial responsibility until the closing, plugging or abandoning of the well. Class VI responsibility addresses corrective action, PISC, site closure, emergency and remedial response
- Requirement to install continuous recording devices, alarms and surface or down-hole shut-off systems or other safety devices
- PISC - This is not a requirement for Class II, this is stated as 50 years for Class VI but depends on the director’s discretion
- Class VI Regulations specify the depths of casing strings and cementing to the surface. Compatibility of well materials with fluids which they come into contact with

Other Regulatory Developments

This report also looked at other regulations or standards which are not part of national frameworks. A key finding was that the London Protocol amendment to allow transboundary movement of CO_2 is still to be ratified, but the legal framework has been in place since 2009, with the amendment to sub-surface offshore storage approved in 2006. In 2011, ISO/TC 265 for carbon dioxide capture, transportation and geological storage was created. The role of the ISO standards is advisory, since they are not binding government requirements, but they have the potential to be useful in a number of different situations, such as informal guidelines for CCS project developers to follow in countries that are still developing their own government regulatory frameworks for CCS.

GCCSI legal and regulatory indicator

Since the last publication of the GCCSI legal and regulatory indicator in 2015, 11 countries have introduced new legislation or made legislative amendments related to CCS, but only seven of those countries have had a change in their GCCSI rating score, out of the 55 countries included in the assessment. The top five countries for CCS regulation are Australia, Canada, Denmark, the UK and the USA, referred to as Band A. The GCCSI states that legal and regulatory models in these countries are "sophisticated and address novel aspects of the CCS process", although the results show these nations have seen little to no change since the 2015 publication. Overall, the GCCSI report concludes there has been little to no material change in the status of CCS legal and regulatory models in many countries worldwide between 2015 and 2018.

Expected Developments

Many significant developments are expected to occur in the next few years. In particular, these could be: the inclusion of avoided emissions from CCS in the US National GHG inventory; update of the British Colombia LCFS to include CCS; the development of a Canadian Clean Fuel Standard at federal level; and the publication of more ISO standards for CCS. In addition, in the USA, the National Petroleum Council has been requested by the US Secretary of Energy to undertake a study on CCUS and the potential pathways leading to CCUS deployment at scale, which will result in a "Roadmap for CCUS Implementation".

Key findings from interviews

Some key themes were identified from the 15 interviews conducted for this study, which included a range of regulators and industry experts. In relation to the overall advancement of the CCS regulatory environment there was a split of opinions between responses as to whether it was sufficiently advanced. Many interviewees believed that some key barriers remain including the insufficient clarity and support around ownership of pore space. Some interviewees felt some regulations were too detailed or too prescriptive.

The majority of interviewees considered current tax credits to be insufficient; one interviewee suggested implementing an investment tax credit in order to further CCS research and development.

When discussing the key barriers, the main issue raised by interviewees was a lack of experience of regulators; a barrier that was also recognised by regulators themselves. As there have been a limited number of projects to date, agencies lack experience in implementing the regulations, so it can be a long process. In addition, identifying gaps or issues in regulations is difficult until enough projects have tested the regulations.

When discussing next steps for the CCS regulatory landscape during the series of interviews undertaken for this report with CCS experts, the following suggestions were put forward by the interviewees [2]

[2] See the Appendix for full list of interviewees

- Incentives such as 45Q are not attractive enough; more money is required to incentivise CCS projects over a longer time horizon
- Projects need subsidising so pilots can be successful and build momentum, so future projects and regulatory agencies can learn from pilot projects.
- More practicality relating to regulations such as 50-year default opposed to 100 years, or more flexibility – it should be acknowledged this was not the view of all interviewees, with one commenting legal flexibility can make industry nervous since they prefer certainty
- Streamlining the regulations while finding the balance between acceptability, protection and project liability.
- There is a role for governments to push CCS; for example, a role for avoided emissions from CCS to be expressly included in national GHG inventories

The following themes were key discussion points of the interviews, and the summary of the key findings of the research and differing viewpoints of the interviewees are summarised below.

Where are the general consistencies in CO_2 storage regulatory approaches?

When comparing the details of CO_2 storage regulations, there are many areas with consistent approaches. Most regulations require some form of proof of financial resources for liability purposes, with operators all liable for leakage during the project lifetime, and expected to rectify this. In general, CCS regulations have a very transparent process for reviewing applications and publishing comments from stakeholders and responding to these. Many regulators commented this was a critical part of developing regulations and approving applications. Apart from the CA LCFS, most regulations include some level of flexibility and discretion in relation to aspects of the framework, for example not a fixed period for PISC, or monitoring plans being approved on a case-by-case basis.

Where are there greatest differences or inconsistencies in regulatory approaches? And what are the reasons for these disparities?

One of the key differences in the regulatory approaches is to PISC, with this varying from 15 to 100 years of monitoring. Another is the approach to long-term liability with some (but not all) regulations allowing transfer back to the state or regulator, but the time frame where this occurs does vary. The CA LCFS CCS Protocol probably entails the most extensive regulations, with the highest level of monitoring requirements. This is due to CARB wanting to ensure the success of the LCFS and not damage the reputation of CCS. In return for it fixed regulatory requirements, CARB indicated that California is "*willing to pay a premium*"[3] via California LCFS credits for complying with the LCFS protocol for emissions sequestered by CCS projects, with the highest value of credits of any program, which currently range from $180-200/tCO_2e. It is worth noting this price is market driven and does fluctuate. In July 2016 it dropped to $67 per tCO_2e, but recently it has had a higher value, with a low of $124 per tCO_2e in the last year, and a low of $171 per tCO_2e in the last 6 months[4].

Another difference is the value of incentives such as 45Q versus CA LCFS, but in general there has been an increase in funding recently, despite withdrawal of other funding mechanisms since the previous CO_2 Capture Project (CCP) regulatory review published in 2015. Overall, this disparity in incentives is due to countries or states having different priorities or being in different stages of developing their regulatory frameworks. For example, the EU Fuel Quality Directive included CCS as part of fuel pathways since 2009, in comparison to the CA LCFS which introduced this in 2018 and British Columbia and Canada which are still developing fuel quality standards and considering the basis for including CCS projects.

[3] Compared to the value of incentives of the California cap and trade system

[4] Between March 2018 and February 2019 and September 2018 to February 2019 for the 12 and 6 month periods respectively

Where are there potential conflicts posed by regulatory requirements?

It is most likely conflicts will occur where operators are looking to introduce projects in the same region or country where states or member states have differing frameworks. One example would be in the USA, where the CA LCFS CCS requirements are more stringent than those of the EPA UIC Class VI well regulations or where states with primacy differ in implementing regulations. However, the CA LCFS is an optional scheme offering an incentive, so this is not necessarily a conflict but a decision to be made by the operator if they are willing to address these issues. In the USA the more likely conflict would come from states which have primacy having slight differences in regulations to the EPA. However, this is hard to determine at the moment, with only one state having primacy for Class VI, but any discrepancies are expected to be minor.

Another possible conflict could be in the EU, with differing legal and regulatory regimes available to support the implementation of the CCS Directive. However, no major conflicts have been identified to date and the final EU Commission review of applications should help to promote consistency.

Finally, another potential conflict is the difference in long-term liability across Australia. The federal regulations allow transfer of liability back to the state, but the state regulations do not allow this. Overall, there are differences in monitoring or well requirements, but these are usually between countries, and are only likely to become material as deployment grows. These disparities are also likely to be tested as more projects are approved and as the regulations get trialled by actual projects and the regulators gain experience.

Conclusions

Overall, regulators are aiming to promote transparency and generally seem to be taking into account comments from key stakeholders when developing regulations. Although many of these regulations have yet to be rigorously tested due to a relatively low level of CCS project deployment, reviews of regulations have been carried out using hypothetical projects (Victoria, Australia) or recommendations from technical panels (Alberta CCS).

Regulations that have been developed are not consistent across the globe, with key disparities relating in particular to long-term liability and post-injection monitoring requirement. Despite this, there are some areas such as the need for proof of financial ability to cover potential liabilities and public engagement which on the whole are being approached in a similar way.

In general, there has been a growth in CCS policy confidence. This can be seen by the development of new regulatory frameworks, in particular incentives such as 45Q. This is also reflected in the growing ambition of certain countries such as the UK, who have created the CCS Council and CCUS Cost Challenge Taskforce to aim to make CCUS economically feasible.

The GCCSI legal and regulatory indicator ranks only five countries as having legal and regulatory models which are sophisticated enough to address novel aspects of the CCS process, showing there is still a considerable amount of development required in many countries, such as Japan and Indonesia, as highlighted in this report.

Guide to the Tables and Boxes in the Report

There are many tables and boxes presented in the main section of the report, which provide further information and comparisons, to what has been summarised in the key findings. These will provide a more context, detail and a wider perspective to the regulations. A list of the key tables and boxes is shown below:

Table 2.1 Comparison between US EPA UIC Class II and Class VI Well Regulations

Table 2.2 Summary of Areas of in the US UIC Class VI Regulations Which Could Vary Between Applications

Box 2 Changes made to the US 45Q CCS Federal Tax Credit in 2018

1. INTRODUCTION

This report has been prepared for Phase 4 of the CO_2 Capture Project (CCP) by Environmental Resources Management Limited (ERM) over the period September 2018 – April 2019.

1.1 BACKGROUND

Founded in 2000, the CO_2 Capture Project (CCP) is an award-winning group of major energy companies working to advance the technologies that will underpin the deployment of industrial-scale CO_2 capture and storage (CCS), currently in its fourth phase (CCP4) which commenced in 2014.

The CCP4 program aims to develop further research and understanding of CO_2 capture solutions in the scenarios identified from previous CCP phases (refinery, heavy oil and natural gas power generation), together with CO_2 separation from natural gas production.

Within CO_2 storage, the CCP4 program will continue to demonstrate safe and secure geological containment through field-based monitoring and developing robust intervention protocols.

1.2 OBJECTIVES AND SCOPE

There is now a wide range of regulations that govern CCS projects across the globe. These regulations have been influenced by multiple regulators, operators and key stakeholder groups. The report includes regulations for permitting and for qualifying CO_2 storage projects for incentives. The focus is on rules and regulations for CO_2 storage projects relevant to the oil & gas as well as other industries, with an emphasis on key learnings, potential gaps and main findings to support the viability of CO_2 storage projects both onshore and offshore in a practical and commercial context. The research is limited to CO_2 injection and long-term storage.

The analysis in this report aims to:

1. Assess how the CCS regulations promote transparency
2. Identify examples that promote consistency
3. Provide a useful reference for jurisdictions that are establishing or modifying their own CCS rules.

The overarching goal of the study is to summarize how CO_2 storage regulations serve to promote safe, effective, and efficient regulation with insights into the consistency or lack thereof across jurisdictions.

1.3 APPROACH AND STRUCTURE OF REPORT

As part of the approach, a range of interviews were undertaken to gain insight from experts in CCS and personnel involved in regulation development. Comments from interviewees have not be attributed to the individual by name, but a list of interviewees can be found in the appendix of the report.

The report covers an initial review of regulations from a range of countries across the world, with identification of gaps and inconsistencies throughout the report. This includes the USA, Canada, EU, Australia, Japan and Indonesia (Section 2-7). The report also reviews the London Protocol, OSPAR Convention and the ISO Standards which relate to CCS (Section 8). This is followed by an analysis section which addresses the main gaps and inconsistencies found throughout the report, summaries the differences between regulations and discusses the key findings in relation to the aims of the report (Section 9).

The report focuses on CCS, but some regulations refer to CCUS. For clarity, a definition of the two terms is provided in Box 1.

Box 1 Defining CCS and CCUS

CCS usually involves three major steps; capturing CO_2 at the source, compressing it for transportation and then injecting it deep into a rock formation or saline aquifer at a carefully selected and safe site, where it is permanently stored.

Capture: The separation of CO_2 from other gases produced at large industrial process facilities such as coal and natural-gas-fired power plants, steel mills, cement plants and refineries. More recently direct air capture technologies have also been developed at a pilot scale.

Transport: Once separated, the CO_2 is compressed and transported via pipelines, trucks, ships or other methods to a suitable site for geological storage. Transport may not necessary if the CO_2 can be stored on site.

Storage: CO_2 is injected into deep underground rock formations or saline aquifer where it will be permanently sequestered, usually at depths of one kilometre or more.

Alternatively, the CO_2 which has been captured can be utilised for a range of purposes, opposed to being stored. This is referred to as **CCUS**. One common use of CO_2 is enhanced oil recovery (**EOR**), which is the process of recovering oil from a reservoir following primary and secondary techniques. CO_2 injection lowers the viscosity of the oil allowing it to flow more easily, and more oil to be extracted. A significant amount of CO_2 will remain in the oil field as a result of CO_2 EOR.

1.4 OVERVIEW OF REGULATORY ISSUES FOR CCS

During the process of undertaking expert interviews and reviewing the current CCS regulatory landscape, it became apparent that there were a range of factors which are addressed differently in various regulatory frameworks. The key factors often addressed differently include:

PISC and Site Closure

Post-injection site care (PISC) and site closure requirements refer to the steps undertaken by a project once injection ceases and the site closes. This includes monitoring requirements, with the primary disparity being the length of time monitoring must continue. After these requirements are met, the liability of the site may be able to be transferred or the permit may be terminated.

Financial Requirements

In order to be granted a permit, some regulators require proof of necessary financial resources to be used to address leakage or environmental damage. This may be as an upfront payment, ongoing payment, or just proof of sufficient funds.

Liability

This is how a project is accountable for potential CO_2 leakage and environmental damage. This may be through direct finance, or through emission allowances or credits. In addition, this also covers long-term liability, so for what period of time post-injection an operator remains liable for any leakage, which may be indefinitely. In addition to this, liability can be transferred in some regulations, for example back to the state.

Public Engagement

As part of the process of approving an application, most regulators undertake some form of public engagement. This typically includes a fixed public engagement period after which responses are required by the regulator or the operator.

Thresholds

Some regulators might exclude some projects from needing to comply, such as those storing under a threshold of CO_2, or some research and development projects. Some regulators have no exclusions, meaning all geologic storage projects must comply.

Monitoring and Reporting

This is the requirements imposed on the operator to monitor during injection as well as the method and frequency for reporting this to the regulator. Some regulators require annual or bi-annual reports, and this can be an electronic report or a verified individual visiting the site.

Pore Space Access

Accessing the rights to pore space has been raised as one of the key barriers to getting a project permitted. Many regulators state it is beyond the scope of their regulations and it is the local or state authority who is responsible for ownership. Some regulators have put terms in place to ensure ease of access to storage sites for operators.

Flexibility

Some regulations allow flexibility in their implementation; for example, PISC could vary between permits. Quite a few regulations allow for the regulating entity to use their own knowledge and make decisions as they see best dependent on the project details, such as geologic conditions.

2. USA

2.1 EPA UIC CLASS VI WELL REGULATIONS

The EPA's Underground Injection Control (UIC) Class VI regulations were finalised in December 2010 as part of the Safe Drinking Water Act. These apply to geological sequestration wells - projects injecting and storing CO_2 underground (this is separate to CO_2 injected underground for enhanced oil recovery (EOR) which requires a Class II UIC permit).

Data for FY17 shows there are only two injection wells in the USA with Class VI permits - both in Illinois[5]. These two Class VI wells are part of the Archer Daniels Midland CCS Project. A further six Class VI permit applications were submitted to EPA and reviewed as part of the Future Gen project, but these projects did not go ahead.

The Class VI UIC well regulations are quite extensive, much more so than the Class II regulations for EOR projects. A summary of the extra requirements needed to conform to Class VI compared to Class II is shown in Table 2.1. The main additional requirements for Class VI permit regulations over Class II are greater financial responsibility, continuous monitoring during operations, more rigorous testing, and 50 years PISC. The Class VI regulations were modelled around the Class VI well regulations for hazardous waste injection.

Owners or operators seeking to transition wells from Class II (EOR) to Class VI (CCS) do not necessarily have to meet all requirements; well construction can be grandfathered but owners or operators must meet all other requirements of the Class VI permits for long-term underground storage of CO_2.

Table 2.1 Comparison between US EPA UIC Class II and Class VI Well Regulations[6]

	Extra requirements of Class VI permits compared to Class II
Permit Information	■ Additional baseline geochemistry and seismic history ■ Requires additional plans such as post-injection site care, site closure, emergency and remedial response plans
Area of Review	■ Class II AOR is a fixed radius of at least 0.25 miles or based on zone of endangering influence ■ Class VI requires computational modelling of AOR and periodic re-evaluation of AOR and corrective action plan ■ Furthermore, requirements of CO_2 compatible materials for corrective action
Financial responsibility	■ Class II requires financial responsibility until the closing, plugging or abandoning of the well ■ Class VI responsibility address corrective action, PISC, site closure, emergency and remedial response ■ Under current SDWA provisions, EPA does not have the authority to transfer liability.
Injection well construction	■ Class VI Regulations specify the depths of casing strings and cementing to the surface. ■ Compatibility of well materials with fluids which they come into contact with
Testing prior to operations	■ Similar requirements, but Class VI requires cores to be taken and a log analyst's report to be submitted ■ Tests are required to verify hydrogeological characteristics of injection zone e.g. pressure full-off test and pump test of injectivity

5 United States Environmental Protection Agency (EPA) (2017) UIC Injection Well Inventory. Available online at: https://www.epa.gov/uic/uic-injection-well-inventory

6 This is based upon the Draft EPA Underground Injection Control Program Guidance on Transitioning Class II wells to Class VI wells, available online at: https://www.epa.gov/sites/production/files/2015-07/documents/epa816p13004.pdf

Operating requirements	■ Requirement to install continuous recording devices, alarms and surface or down-hole shut-off systems or other safety devices
Mechanical integrity testing	■ Requires continuous monitoring for internal integrity and annual external MIR. Only required at least once every 5 years for Class II
Operational testing and monitoring	■ Continuous monitoring of injected fluids, injection pressure, flow rate, cumulative volume, plume and pressure front tracking, surface air monitoring and soil monitoring at the UIC program director's discretion; and corrosion monitoring and ground water quality monitoring ■ Class II monitoring is daily, weekly or monthly dependent on the type of operations
Reporting	■ Class II requires an annual report submitted, whereas Class VI requires a semi-annual monitoring report, electronic report and recordkeeping
Well plugging	■ Class VI requires compatibility of the plugging material and pre-plugging activities such as notice of intent to plug and a plugging report
PISC and site closure	■ This is not a requirement for Class II, this is stated as 50 years for Class VI but depends on the director's discretion
Emergency and remedial response	■ Class II requires contingency plans to cope with well failures, but Class VI requires other potential risks in the AOR such as risks from the pressure front

2.1.1 Areas of Disparity

There is a wide range of factors which influence the permit process which can lead to discretion in permit conditions between different applications. Some of the key factors which may vary are detailed below and also outlined in Table 2.2.

Application Time

The Archer Daniels Midland (ADM) permit was the first Class VI permit, with the application taking approximately five years. As this was the first such application, it was likely to take a longer time due to a lack of experience in the EPA team who were processing the permit. One person involved in the ADM Class VI application described the process as "intense", requiring a lot of information and plans, but ADM worked closely with the EPA and sought to address issues in advance. Multiple model iterations were required, which are still being undertaken during injection.

Another interviewee suggested there were two typical reasons for a delay in the application process involving stakeholders and the EPA. Stakeholders may challenge the permit through the mandatory comment periods, or they could delay getting rights to the land or pore space. The EPA has a lack of experience due to few permit applications, with the interviewee commenting more training of staff could be beneficial. At the same time, the interviewee recognised this was a complicated process requiring technical judgement and difficult decision making. Interviewees also commented that Class VI wells have often been "Greenfield" sites, so there is less geologic knowledge, meaning plume modelling and testing takes longer. In contrast, another interviewee commented that they believed the regulations relating to injection and monitoring are over-regulated and over-prescriptive.

The interviewee involved in the ADM permit explained how the EPA used the STOMP reservoir modelling package, whereas ADM were using ECLIPSE, The two approaches produced results which were different due to varying assumptions made by the models, comparing these outputs took time and therefore slowed the process. The interviewee felt the EPA had no intention to slow the application, but was simply aiming for perfection. The EPA Region 5 team was described as great to work with, but the inexperience of the other EPA regions is likely to result in slow initial permit applications in those regions.

While EPA staff acknowledge that issuance of the ADM permit took several years, they emphasize that the process served as a valuable learning experience for both the Agency and the applicant. Since the ADM permit application was developed and submitted to the EPA, the Agency has developed a suite of guidance materials to facilitate a more transparent, efficient permitting process. The EPA has also developed a tool (the Geologic Sequestration Data Tool) to facilitate: the submittal of information by Class VI permit applicants and project operators; the development and management of a robust administrative record for each permit; and the storage of all project-related data in one location. EPA anticipates that there is substantive benefit in an applicant's awareness and use of the tools available to them in advance of application submission resulting in the submittal of more complete and informed applications. Moreover, the EPA commented that they encourage early communication with the permitting authority, be that the EPA region or a state with primacy, so technical support can be provided. The EPA acknowledged that just as an applicant's process of developing and submitting a Class VI application is likely to be a multi-year process that varies from project to project, EPA's review will also require the requisite time to ensure that the EPA comprehensively evaluates the submitted data and information and establishes environmentally protective permit conditions. In contrast, Class II permits are a much quicker process, particularly in some states such as Texas, typically taking a matter of weeks.

However, not very many permit applications have been submitted or approved to date, making it hard to determine an average time. It should be acknowledged that permits will vary case by case, with project characteristics such as the geology having a large influence over the extent of modelling required, data collection and planning, which will also impact the application time.

Director's Discretion

The Class VI regulations make several references to the "Director's discretion" referring to the Director of the UIC Program having the ability to make a decision on the requirements of parts of the regulations. This was introduced as a result of the stakeholder engagement during the regulatory development process for Class VI permits which commenced in 2007. In the 180-day public comment period, the EPA heard from a range of academics, NGOs, and industry representatives that the regulations needed flexibility to deal with differences between projects such as geology. This means that permits may have slightly different requirement dependent on what has been deemed necessary by the Director.

One example is the post-injection site care (PISC) period, which is 50 years as a default, but applicants can propose a different time length, or can demonstrate during the PISC period that the timeframe should be modified. An interviewee commented the 50-year time period may put people off so this should be rephrased to make it clear that it relates to plume stability and could theoretically be as short as ten years.

The flexibility represented by Director's discretion can be seen as a good thing, as it allows discussion about the terms of the permit and means the regulations are less prescriptive. However, this could ultimately lead to differences between projects during the application process, as this process is subjective and opinions between directors may vary. Nonetheless, all permits will still meet the requirements needed to ensure safe storage of CO_2.

Public Engagement

The EPA's Class VI rulemaking process and the final Class VI regulations ensured opportunities for public and other stakeholder engagement. During the Class VI Rulemaking, multiple public comment periods afforded the opportunity for public comment. All of the comments submitted to the Agency and EPA's responses are available to the public which promotes a very transparent regulatory process. Additionally, during Class VI permitting, the public and stakeholders have the opportunity to comment on individual permits. Public notice and comment are important to the EPA as they provide for transparency and also ensure that no new, critical information is missed.

The final Class VI rule preamble (75 FR 77230) included language related to an "adaptive rulemaking"; i.e., that the Agency would "review the rulemaking and data on GS projects to…determine if modifications to the Class VI UIC requirements are appropriate or necessary". The EPA clarified that any future rulemaking would require stakeholder engagement including public notice and comment. At the time of this publication, the agency confirmed that they are not currently updating the regulations.

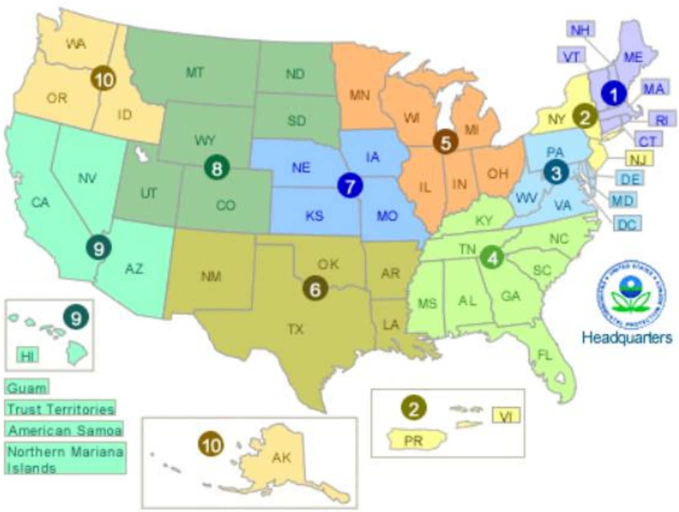
The level and extent of public comments on an application will depend on the local community. An interviewee commented that communities with existing subsurface activities are often more knowledgeable with the potential project risks and are more likely to see the link to economic benefits such as jobs. In these cases it may be less likely projects that in these locations will be slowed due to public opposition. The UIC regulations have a clause relating to updating the regulations if and when required, based on when the EPA feels there is sufficient knowledge or experience to update them. The EPA state they would again engage with stakeholders during this period, but they are not currently contemplating updating the regulations at this time.

Primacy

As part of the UIC program, states, territories or tribes can apply for primary enforcement (primacy). This refers to when the state/territory/tribe has responsibility for implementing the EPA UIC program. North Dakota is the only state so far with primacy for Class VI, but they have not issued any Class VI permits yet; Region 5 is the only EPA region to have issued Class VI permits. The states and the regions they sit within for the EPA, including the UIC program, are shown in Figure 2.1.

When conducting this study, it was the view of some interviewees that primacy is applied for if states would like to be in control of the process, most likely looking to make the process quicker, which may displease NGOs. In contrast another interviewee commented that the view of Class VI well permits was very pessimistic by the public in North Dakota, but they believe the opinion has improved now being more positive, with the public having more trust in the state regulators to implement the rules opposed to the federal government [7]

Figure 2.1 EPA Administrative Regions including the UIC Programme[8]



The numbers refer to the EPA administrative regions, of which there are ten.

[7] This is just an observation and the view of an interviewee, this is not a fact

[8] United States Environmental Protection Agency (EPA) (2018) Primary Enforcement Authority for the Underground Injection Control Program https://www.epa.gov/uic/primary-enforcement-authority-underground-injection-control-program

Pore Space and Trespassing

One issue that is less covered in the regulations is access to pore space, with there being disparities between states on pore space ownership, whether this is held by the land or sub-surface owner. There is currently no guidance on this, or a standard approach, which can mean some permit applications take longer than others. The CCS project developer is not required to own the pore space but must have obtained legal access to the pore space under a commercial arrangement. There can be further complications if there are multiple land owners. Overall this topic can be something which companies are quite unfamiliar with. This then leads to concerns relating to trespassing in particular for long-term monitoring. One argument for this is whether the pore space is too deep in the ground for someone to have ownership of it, in a similar way that judges have overruled complaints from people relating to airplanes in their airspace, due to the planes being too high for them to have ownership. The EPA states that pore space falls into one of the categories that is outside of the scope of the authority, which implies this is not a regulatory discrepancy or barrier, but a variation in state laws on land ownership left to be resolved locally.

Table 2.2 Summary of Areas of in the US UIC Class VI Regulations Which Could Vary Between Applications

Reason for disparity	Example	Further information	Comment on gaps or discretions
Application time	Differences in location	A large amount of information on the proposed site is required including: ■ Maps and cross sections of the area of review (AOR) ■ Location, orientation and properties of faults and fractures ■ Geo-mechanical data including information on fractures, stress, rock strength ■ Data on injection and confining zone such as depth, thickness, porosity, mineralogy ■ Seismic history of the area ■ Geologic and topographic maps, including regional geology and hydrogeology ■ Maps and stratigraphic cross-sections of all underground sources of drinking water ■ Geochemical data on subsurface formations	More details are required on hydrology and geochemistry. The time and effort to get this data will vary with location.
	Modelling	As part of the AOR and corrective plan, a range of models are required including: ■ Method for delineating the AOR, including model, assumptions and data used ■ Minimum fixed frequency, at least once every five years that the owner or operator re-evaluates the AOR ■ Site and project specific monitoring and operational conditions which would warrant a re-evaluation ahead of schedule ■ How corrective action will be conducted and how this will be adjusted if there are changes to the AOR	Review of the detailed models will take time and will also vary with location. Getting these results to also align with the EPA can be difficult, in particular if different models are being used. Also, the AOR is not a fixed size, adding further variation
Director's discretions	Post-injection site care	PISC must be undertaken for 50 years or an alternative timeframe approved by the director at their discretion based on site-specific data and modelling. This is one of many things which is at the Director's discretion.	This allows the process to be flexible, and reduce the time and effort required if suitable. This can result in different requirements for different projects and variation between permits

Reason for disparity	Example	Further information	Comment on gaps or discretions
Public Engagement	Public comments	The extent of public comments will vary depending on the local population density, their knowledge on CCS and geological storage along with a range of other factors	This could delay the permit process, but it is unlikely to prevent the permit going ahead
Primacy	Post-injection site care	PISC must be undertaken for 50 years or an alternative timeframe approved by the director at their discretion based on site-specific data and modelling. This will vary depending when the plume stabilises.	This will also vary between EPA and states which have primacy, depending on whether states with primacy decide to be more stringent
Pore space and trespassing	Access to underground storage	EPA states pore space access falls out of scope of the authority, this means there is little to no guidance or assistance on the matter. States regulations vary across the US, resulting in variation between the process which the operator or owner must undertake.	Gaining access may be easier in states where there is primacy or a larger number of projects with subsurface access e.g. EOR projects

2.1.2 Observation and Potential Areas for Improvement

Application time is an area of concern for those considering submitting a Class VI UIC permit application for a CCS project in the USA. The EPA anticipates that the suite of Class VI guidance documents, the Geologic Sequestration Data Tool, and the Agency's experience in permitting multiple Class VI projects will improve efficiency of Class VI permit application reviews.

Variation in permit application time is still likely to occur due to variation in physical conditions including geology, but also differing modelling techniques. Further variability could also be introduced by different requirements due to Director's discretion, but this may also reduce time, with the possibility that some projects do not have to carry out unnecessary steps that are not relevant to their site or location.

The Class VI well regulations are considered to be very transparent, with opportunities for public engagement. The view of the local community may impact the time taken to get approval for a permit, as they could oppose the project and slow the process. Alternatively, valuable additional information may be introduced which could alter the application. The state in which a project is based in may also impact the permit application. Primacy in a state may influence the approval speed or process. As there have been no permits in North Dakota since it received primacy, the influence this will is hard to determine. In relation to gaining access or ownership of pore space, often project operators or owners are unfamiliar with this process, and the variance between states can further slow applications down.

In addition to interviewees commenting on their views on the regulations, some also commented on how the Class VI regulations could be improved. One interviewee, who was not an employee of the EPA, commented that small projects which are storing small quantities of CO_2 should be exempt from Class VI regulations and moved to another class such as Class V, which are for underground injection of non-hazardous fluids. The EPA confirmed that the appropriate well classification for CO_2 injection following promulgation of the final Class VI rule was a topic that the Agency addressed and sought comment on during the Class VI rulemaking process[9]. The EPA also clarified that, at the time of rule promulgation, the Class VI regulations at 146.81(c) required owners or operators of Class V experimental technology wells no longer being used for experimental purposes to apply for Class VI permits (75 FR 77230). EPA acknowledged that there is an assumption that Class VI permits will take a long time, but this may not necessarily be the case.

The consensus of the interviewees was that with a small number of approved Class VI projects, it is difficult to plan on the amount of time needed for permit review and why some projects go through but others do not. One interviewee stated they believed that of the projects that did not move through permitting, most were stopped due to business reasons including a mismatch in the timing of key go/no-go decisions and permitting decisions .The small number of projects also makes it difficult to determine with any certainty the reason for variation in the application time and process and how this may develop over time. Finally, the EPA clarified that the existing Class VI regulations are able to address CO_2 injection for geologic sequestration in the United States.

2.2 45Q TAX CREDITS UNDER THE US FEDERAL TAX CODE

The US budget bill passed by Congress and signed into law by President Trump in February 2018 included the FUTURE Act, which extends and reforms the Section 45Q US Federal tax credit for CCS projects in the US. This revamped 45Q US CCS federal tax credit seeks to incentivise private investment in commercial deployment of technologies to capture carbon dioxide (CO_2) from power plants and industrial facilities for enhanced oil recovery (CO_2-EOR), other forms of geologic storage and for beneficial uses of CO_2.

The FUTURE Act provides additional financial certainty for private investors and developers of carbon capture projects by: lifting the current cap on available 45Q US tax credits, and increasing their value

[9] Please refer to the following link for further information: www.regulations.gov/docket?D=EPA-HQ-OW-2008-0390

for each ton of CO_2 captured and safely stored or put to beneficial use. The incentive is performance-based, so only projects that successfully capture and store CO_2 can claim the credit.

The specific changes made by the FUTURE Act to the 45Q CCS US federal tax credit are detailed in Box 2.

Box 2 Changes made to the US 45Q CCS Federal Tax Credit in 2018

1. Increased credit value and expansion of credit to beneficial uses of CO_2 in addition to enhanced oil recovery (EOR):

- 10-year ramp up to $35 per ton for CO_2 stored geologically through EOR.
- 10-year ramp up to $35 per ton for other beneficial use (see 'Utilization' below for carbon reduction requirements) such as converting carbon emissions into fuels, chemicals, or useful products like cement.
- 10-year ramp up to $50 per ton for CO_2 stored in other geologic formations and not used in EOR or for other purposes.
- Post-2026 the credit will be adjusted to increase with inflation.

2. Removed credit cap and clarified timing for eligibility.

- No cap on total credits that can be claimed under 45Q.
- Eligible projects that begin construction within seven years of the enactment of the FUTURE Act (i.e., before January 1, 2024) can claim the credit for up to 12 years after the carbon capture equipment is placed in service.

3. Expanded eligibility to more industries by lowering the carbon capture threshold and expanding the definitions for qualified facilities and qualified carbon. The thresholds are:

- 25,000 – 500,000 metric tons: Beneficial use projects other than EOR.
- At least 100,000 metric tons: All other industrial facilities, including direct air capture (other than electric generating units).
- At least 500,000 metric tons: Electric generating units.
- The type of carbon that can be captured is expanded to include other carbon oxides beyond carbon dioxide, including carbon monoxide.

4. Provided greater flexibility to determine which entity can utilize the tax credit, enabling the accommodation of different ownership and business models for carbon capture projects.

- The owner of the carbon capture equipment is the recipient of the credit; the recipient can allow another entity involved in storing or beneficially utilizing the carbon to claim the credit.
- The original 45Q tax credit remains available until the credit runs out under the prior cap that applied to 45Q.

The credit can only be claimed for the amount of carbon emissions that are captured and permanently isolated or displaced from the atmosphere, as determined by lifecycle greenhouse gas accounting. This is an increase in tax credit value over the original 45Q. It also opens up the credit to a broader array of industries that can beneficially use the CO_2, such as converting CO_2 into products. The 45Q tax credit now applies to projects that store captured CO_2 in geological formations unrelated to EOR, thus providing a value for CO_2 storage beyond EOR or beneficial utilization.

2.2.1 Value of Incentives

The increase in 45Q tax credits makes CCS projects more attractive for investors and may incentivise new projects. From the interviews undertaken for this study is it the view that 45Q will be good for chemical and ethanol industries, but many not be sufficient for iron, steel, power, and oil industry needs. Interviewees also stated that they had heard of projects being discussed which had not had interest before the 45Q tax incentive was increased.

2.2.2 Commencing Construction

There may be some concern over the ambiguity of the phrase "commence construction" and what is expected of a project to receive the tax credit ahead of the deadline on 1st January 2024. Some interviewees were less concerned about this, suggesting it may not have to be major equipment. In addition if the tax credit is extended this also becomes less of an issue, although there is no suggestion of an extension currently. In addition, with the UIC Class VI permit having taken five years to approve in the past, this might also be an issue, taking the timeline beyond the 45Q deadline and with companies not ethically wanting to commence construction without a storage permit.

2.2.3 Summary regarding 45Q

Based on the successful enactment of the FUTURE Act in February 2018 to extend and expand the 45Q US federal tax credit for CCS, a new US industry group (the Carbon Capture Coalition, successor of the National Enhanced Oil Recovery Initiative) is seeking to do more to incentivize CCS in the US, including:

- Enacting complementary federal and state incentives to the revamped 45Q tax credit to attract greater private investment in carbon capture projects, such as tax-exempt private activity bonds and master limited partnerships that are currently available for other energy technologies and infrastructure;
- Engaging in federal infrastructure policy deliberations in the coming months to ensure that carbon capture and CO_2 pipeline infrastructure are part of the equation;
- Maintaining robust federal support for carbon capture research, development, and demonstration to help bring the next generation of carbon capture technologies into the marketplace; and
- Working with governors, state policymakers and local stakeholders to support deployment of carbon capture, pipeline infrastructure and CO_2 utilization and storage projects in states and regions around the country.

In sum, the recently extended and expanded 45Q federal tax credit for CCS project in the US is expected to be a significant factor for the commercial development of CCS projects, and industry is seeking to broaden this even further as noted above.

2.3 CALIFORNIA LOW CARBON FUEL STANDARD

On 27th September 2018, the California Air Resources Board (CARB) posted its final regulation order [10]for the updated California Low Carbon Fuel Standard (LCFS). The original standard required a 10% reduction in carbon intensity of transportation fuels by 2020, which has been increased to a 20% carbon intensity reduction by 2030 in the updated standard. This is in line with California's target to reduce GHG emissions 40% below 1990 levels by 2030.

As part of the update to the regulations, CARB included amendments which incentivise zero emissions vehicle sales and infrastructure. This also included a new CCS Protocol under the LCFS program, allowing sequestered emissions from a qualified CCS project to be recognised.

The value that can be realised by a CCS project developer under the LCFS CCS Protocol is the value of the LCFS credits awarded as a result of CO_2 sequestered by CCS. LCFS credits in California are currently costing about US$180-200 each.

The number of LCFS credits which a company receives is equivalent to the tonnes of CO_2 sequestered. However, any CO_2 losses from breakthrough gases, or operation are deducted. For EOR it is possible that the amount of credits generated could be as low as 50% of captured emissions due to EOR operations emissions. Each company or project will have to work this out as part of their

[10] California Air Resources Board (CARB) (2018) Low Carbon Fuel Standard. Available online at: https://www.arb.ca.gov/regact/2018/lcfs18/fro.pdf?_ga=2.228392533.931106071.1546515576-1709021208.1536658841

fuel pathway registered under the LCFS, and the number of credits a project receives after CO_2 losses are deducted will be determined on a case by case basis.

The new California LCFS CCS Protocol applies to alternative fuel producers, refineries, and oil and gas producers that capture CO_2 on-site and geologically sequester CO_2 either on-site or off-site. The protocol also includes direct air capture. The golden rule as termed by CARB is that the capture entity always generates the credits. For direct air capture, the number of credits received will be equivalent to the tonnes of CO_2 sequestered.

For fuel producers to be compliant, the project must meet all the requirements throughout the project lifetime in accordance with permanence requirements of the CCS Protocol. The key requirements of projects under the CA LCFS are outlined below in Box 3.

Box 3 Key Features of the CA LCFS CCS Protocol

Record keeping: 1) Annual report of sequestered CO_2 2) Quarterly volumes of fuels delivered to California 3) Energy use and chemical data of the carbon capture and CO_2 injection facilities.
Invalidation: Credits for verified GHG emission reduction can be invalidated if sequestered CO_2 associated with them is released or otherwise leaked.
Responsibility: Beyond 50 years post-injection, the project operator is no longer responsible to make up any credits found to be invalid due to leakage.
Verification: Projects must undergo annual verification in order to receive credits.
Public comments: Public comments will be accepted for 10 calendar days following the date on which the application was posted. Only comments relating to potential factual or methodological errors may be considered. The applicant has 30 days to respond.
Boundaries: CCS can occur anywhere within the project lifecycle and does not have to occur in California, as long as the fuel is sold there. Credits are pro-rated in line with the proportion of total fuel volume entering California for use.
Well construction: Required to submit a well construction plan. Operators must consider a range of factors including: size and grade of casting strings, depth of sequestration zone, injection pressure, lithology, cement and cement additives, and chemical and temperature of CO_2 stream.

2.3.1 Active Injection under the CA LCFS CCS Protocol

The CA LCFS CCS Protocol focuses on two key guidelines relating to active injection: site certification and well drilling and operation. Site certification requires that a suitable CO_2 storage site is selected and leakage risk is assessed, via a range of methods for monitoring and modelling. There are also provisions to ensure that the project will not impact local residents. For the injection wells, the Protocol requires them to be properly drilled using correct materials, and any legacy wells be plugged and remediated. These regulations are not dissimilar to the US EPA UIC Class VI regulations.

2.3.2 Monitoring, Liability and Buffers

As part of the CCS Protocol, monitoring to ensure the stability of the CO_2 plume and track leakage if relevant, must occur for 100 years post injection. Whilst the plume is stabilising, significantly more stringent monitoring is required. Once the plume is stable, the wells can be plugged and abandoned, with monitoring reduced to a lower level, which remains in force at this lower level for the rest of the 100-year period. The monitoring burden on a project developer under the CCS Protocol is reduced once the CO_2 plume is stable underground.

Liability for the payback of LCFS credits for CCS leakage is dependent on how many years post-injection the leakage occurs. The operator is only liable to pay back credits for the first 50 years post-injection completion if leakage occurs. The CA LCFS CCS Protocol has a buffer account, which is an assurance pool of LCFS credits that all CCS projects contribute to. The amount of credits paid into the buffer account depends on the project's risk rating which is dependent on the project.

Prior to 50 years post injection, credits from the buffer account up to and including the project's total contribution can count towards leakage-related credit invalidation. If the leakage exceeds this contribution to the buffer account, the project operator must retire any outstanding credits.

After 50 years post-injection, the CCS project operator is no longer responsible for credits found to be invalid due to leakage. Other credits from the buffer account can be used to cover this leakage. Thus, the burden on CCS project proponents under the CA LCFS after 50 years is only lower level monitoring, not liability for credits if there is post-closure leakage after 50 years. However, physical remediation must occur if there is a leak, for the entire 100 years post-injection.

2.3.3 Public Engagement under the CA LCFS

The update to the CA LCFS commenced in early 2016. This included a public 45-day comment period. All comments were reviewed and where necessary changes were made. This included comments from fuel suppliers who were aiming to improve and support the CCS protocol, in particular with comments on the 100 year monitoring duration. The Western States Petroleum Association (WSPA) submitted an alternative but this was dismissed in the environmental analysis. Documents which responds to all comment periods has been produced to ensure complete transparency[11]. CARB indicated they wanted to make the latest version of the regulations as CCS friendly as possible, whilst fully protecting the environment, to promote projects. The final draft was then released on 27th September 2018. The CA LCFS update was published in the California Register and became a regulation as of 1st January 2019.

In addition to reviewing the new draft LCFS regulations, the public can also comment on individual applications. After the Executive Officer of CARB accept an application as complete, the application will be made available on the LCFS website, where public comments will be accepted for 10 calendar days. Only comments related to potential factual or methodological errors may be considered. The LCFS Executive Officer will forward the applicant all comments, after which the applicant has 30 days to submit revisions or submit a detailed written response to the Executive Officer of CARB why no revisions were necessary.

2.3.4 Verification under the CA LCFS CCS Protocol

As part of the CCS Protocol, projects must be verified. This process involves certified verifiers going on site to assure what has been submitted as part of the reporting process including determining the carbon intensity reduction value is correct. This is done on an annual basis, or quarterly if projects want to receive credits more often, but the optional quarterly verification would of course entail additional cost to the CCS project operator.

Ahead of the project commencing injection, an independent review of the site will be undertaken, including reviewing the geology and modelling. This must occur ahead of the application being accepted in order to ensure that the project is in line with Site Certification requirements in the Protocol. A professional engineer will also review the well records, look at the well logs and check that the site is complying with its plan and with the Protocol.

2.3.5 Impact of the CA LCFS CCS Protocol

Representatives of CARB were interviewed as part of this project to help understand the motivation for the CCS Protocol and get a better understanding of the process. It is their view that the updated CA LCFS would advance regulatory certainty around CCS and that before there were insufficient incentives. The ethanol industry was identified as the main driver by the employees of CARB,

[11] California Air Resources Board (CARB) (2018) Responses to Comments on the Draft Environmental Analysis for the Amendments to the Low Carbon Fuel Standard and Alternative Diesel Fuel Regulations. Available online at: https://www.arb.ca.gov/regact/2018/lcfs18/rtcea.pdf

commenting that they brought the opportunity forward to them, but NGOs also played a significant role.

CARB aimed for the CCS Protocol to be the most robust regulation released to date, for the benefit of environmental integrity but also reputation of the technology. If the first CCS project fails, it could damage integrity of CCS, which CARB acknowledged is potentially very important for climate change mitigation. CARB indicated that California is *"willing to pay a premium*"[12] for complying with the LCFS protocol, with the highest value of credits of any program, which currently range from $180-200/tCO_2e (referring to the market price of California LCFS credits per tonne of CO_2e sequestered by qualified CA LCFS CCS projects).

CARB acknowledged that 100-year monitoring could be controversial, as it was raised by many stakeholders during the public comment periods and even referred to as "the most significant obstacle to project development" by one joint review from a coalition of global companies[13]. However CARB noted the importance of making sure that that "a sequestered tonne is the same as an avoided tonne or a tonne never produced in the first place", hoping this would also appease stakeholders. This approach is aligned to the approach for forestry which was used as one of the guiding provisions when producing the CCS protocol, due to it being the only other non-avoidance based credit.

Moreover, the stakeholder process to produce the updated regulations was considered to be "hugely influential" to the final draft. CARB will be monitoring how technology advances and industries move forward, with regulatory updates expected in the next decade as a result of any knowledge gained.

In comparison to other regulations, CARB does not require a UIC Class VI permit, but the requirements are above and beyond those of Class II. It is worth nothing the EPA however would require the relevant Class II or Class VI permit. CARB aims to work with EPA regions or states with primacy to ensure projects entering the LCFS system are as non-duplicative as possible.

The cap and trade scheme is a separate regulation from the LCFS in California. CARB's aim is that projects would be able to receive incentives under both regulations, with the hope to introduce the same CCS protocol with minor edits to the cap and trade scheme. However this is still under development.

The CCS Protocol of the CA LCFS if a voluntary standard, so there is no level of discretion or any projects which are excluded due to thresholds. It is aimed at both the biofuel and the fossil fuel industry. Interviewees at CARB commented that economic barriers in the power sector, which is separate from the fuel sector, still remain.

As this is a new regulation, it is currently unknown how long a project application will take under the CCS Protocol. CARB will try to accommodate expedited review of fuel pathway applications including CCS as they are likely to be low carbon intensity scores. Overtime CARB aims to learn the best way to dialogue with applicants and understands there will be differences in application time due to complexities from differing geological conditions etc.

CARB indicated that they hope the CA LCFS will help deployment and development in the CCS industry and California is willing to take the lead. Other interviewees outside of CARB believe it could "weed out the eligibility of small projects." It is thought there will be strong interest from "double dipping with 45Q" under the LCFS. Overall, the opinion of the interviewees is that CARB has produced a robust set of regulations, but some projects could have a lot of work ahead of them in order to comply.

CARB have been able to confirm that they are actively working with a number of entities and have received broad interest from all types of sequestration reservoirs and types of capture, with the hope

[12] Compared to the value of incentives of the California cap and trade system

[13] Joint comments produced by: Stanford, Oxy, White Energy, EBR Development LLCS, NRDC, Clean Air Task Force, Centre for Climate and Energy Solutions, Shells, Conestoga, Global CCS Institute, Chevron and California Resources Corporation. This was submitted to CARB on 30th May 2017.

to qualify for the CA LCFS in the short-term. It is yet to be determine to what extent applications, successful or rejected, will be disclosed, but CARB are very willing to actively engage with companies and will happily share any pitfalls in these discussions. The public will be involved in the applications, likely relating to the pathway approval process and permanence certification.

2.4 USA GREENHOUSE GAS REPORTING PROGRAM

The US Greenhouse Gas Reporting Program (GHGRP) requires reporting of greenhouse gas (GHG) data and other relevant information from large GHG emission sources, fuel and industrial gas suppliers, and CO_2 injection sites in the United States. The reported data is made available to the public[14]. Facilities must determine if they are required to report based on a range of criteria:

- GHG emissions from covered sources exceed 25,000 metric tons CO_2e per year.
- Supply of certain products would result in over 25,000 metric tons CO_2e of GHG emissions if those products were released, combusted, or oxidized per year
- The facility receives 25,000 metric tons or more of CO_2 for underground injection per year

Facilities required to report their GHG emissions must submit such reports each year directly to the EPA via an online tool e-GGRT. Prior to submission, there are multiple checks built into e-GGRT that provide data validation. After submission, EPA electronically verifies the data through the use of statistical, algorithm, range, and other verification checks. When needed, EPA conducts direct follow-up with facilities concerning potential data quality issues.

2.4.1 Reporting for Carbon Capture and Storage

Two subparts of the GHGRP (UU and RR) are relevant for CCS projects - defined in Box 4.

Subpart UU of the GHGRP is for reporting CO_2 received for injection by EOR and other similar projects.

Subpart RR of the GHGRP is for reporting CO_2 sequestered for the purpose of geological storage.

The CO2 Capture Project published a study in 2016 Best Practice in Transitioning from CO2 EOR to CO2 Storage, Report for CCP4 Policies and Incentives Working Group, 30 March 2016, which explored policies in regulations around the world, including the US EPA, focused on EOR and regulatory practices that could enable a transition to CO2 storage.

Box 4 Definitions of Subpart UU and Subpart RR under US Greenhouse Gas Reporting Program[15]

Subpart UU
Underground **injection of CO_2** underground for enhanced oil recovery (EOR), acid gas injection/disposal, carbon storage research and development and for any other purpose other than geologic sequestration

Subpart RR
Geologic **sequestration of CO_2** including a mechanism for monitoring and reporting to the EPA amounts of the long-term containment of carbon dioxide in subsurface geologic formations

The first reporting period for Subpart RR was 2016. In the 2017 reporting year, three projects reported under subpart RR: two Occidental Petroleum EOR projects and the ADM CCS project in Illinois. In addition, the EPA approved a further 2 MRV plans for projects to report under subpart RR in 2018.

[14] United States Environmental Protection Agency (EPA) (2018) GHG Reporting Program Data Sets. Available online at: https://www.epa.gov/ghgreporting/ghg-reporting-program-data-sets

[15] United States Environmental Protection Agency (EPA) (2018) Capture, Supply and Underground Injection of Carbon Dioxide. Available online at: https://www.epa.gov/ghgreporting/capture-supply-and-underground-injection-carbon-dioxide

These are an Exxon Mobil Acid Gas injection project and a Core Energy EOR projects approved in June and October 2018 respectively.

CCS facilities reporting to Subpart RR are required to submit a plan to the EPA for monitoring, reporting and verification (MRV). After a CCS facility's MRV plan is approved by the EPA, projects must then report information on CO_2 received for injection, data relating to amounts of CO_2 sequestered and annual monitoring activities. The GHGRP is separate from the UIC well regulations, however the MRV plan can address both UIC and subpart RR requirements or projects can choose to have separate plans. R&D projects can apply for exemption under subpart RR.

For Subpart RR, discontinuation of reporting depends on the class of well. For Class VI wells, facilities provide a copy of the applicable UIC program Director's authorisation of site closure for the UIC Class VI well. For non-Class VI wells facilities must make a demonstration that current monitoring and models show that the injected CO_2 stream is not expected to migrate in the future in a manner likely to result in surface leakage.

While some in the oil industry have indicated that Subpart RR is too onerous, an interviewee thinks that Subpart RR can be used for EOR operations

2.5 US NATIONAL GHG INVENTORY

Data collected as part of the GHGRP is then used as the key source to produce the US National GHG Inventory which is compiled by the US EPA. The US National GHG Inventory is prepared according to rules adopted under the U.N. Framework Convention on Climate Change (UNFCCC) and National Inventory Guidelines issued by the Intergovernmental Panel on Climate Change (IPCC) last updated in 2006. The 2006 IPCC Guidelines for National Inventories were endorsed by the UNFCCC in 2011 and first applied in 2015.

The current US National GHG Inventory published in April 2018 uses data from 2016, the 2017 data is being used to create the next inventory. The Inventory includes historic data starting in 1990 and inventories show the change in emissions from 1990 to present day. The national inventory using 2017 data has undergone a review and will be released in April 2019.

2.5.1 Role of CCS in the US National GHG Inventory

In the 2016 US National GHG Inventory, carbon dioxide transport, injection and geological storage is referenced in a box within the energy chapter[16] based on data reported annually to EPA through its Greenhouse Gas Reporting Program (GHGRP)[17]. The carbon dioxide stored by CCS is not avoided or subtracted from the US national GHG inventory at present; in 2016, CO_2 stored by CCS accounted for 3.1 million metric tonnes in the US GHG inventory.

Including CO_2 sequestered by CCS as avoided emissions is being considered by the EPA for future inventories, as mentioned in the Inventory report "EPA will continue to evaluate the availability of additional GHGRP data and other opportunities for improving the emission estimates", but the EPA is unsure how long it would take to decide on future inclusion of CCS as avoided emissions.

2.6 GAP ANALYSIS AND SUMMARY - USA

The Global CCS Institute Legal and Regulatory Indicator

The Global CCS Institute produce a CCS legal and regulatory indicator report[18] which assesses the state of CCS legal frameworks, law and regulation. The latest report in 2018 assesses 55 countries.

[16] United States Environmental Protection Agency (EPA) (2018) *Chapter 3. Energy.* See Box 3-7 on page 3-76 available online at https://www.epa.gov/sites/production/files/2018-01/documents/2018_complete_report.pdf

[17] See https://www.epa.gov/ghgreporting

[18] Global CCS Institute (2018) CCS Legal and Regulatory Indicator (CCS-LRI). Available online at: http://decarboni.se/sites/default/files/publications/202111/ccs-legal-and-regulatory-indicatorglobal-ccs-institute-2018digital.pdf

The USA is in the top band but its score remains unchanged since 2015, suggesting no advancement in the legal and regulatory regime, however this does not take into consideration the CA LCFS which was published just prior to the release of the GCCSI document. The report expresses that further amendments and gaps will need to be addressed to improve the federal regime, where there is a mix of different existing authorities that represent an incomplete regulatory framework. Many of the remaining gaps will need to be addressed at the state level.

Putting the Puzzle Together

A report produced by the CO_2-EOR deployment work group in December 2016, focuses on state and federal policy drivers needed for the growth of America's carbon capture and CO_2-EOR industry. The working group consists of 14 states[19] leading private sector stakeholders and CO_2-EOR experts. A range of challenges facing deployment were identified including high capital costs, low revenues from CO_2 sales due to low oil prices and limited availability of debt and equity for projects due to policy uncertainty and market risk. In response to this, the working group identified a package of incentives to address these challenges. These included:

- Improving and expanding an existing tax credit for storage of captured CO_2;
- Deploying a mechanism to stabilize the price paid for CO_2—and carbon capture project revenue—by removing volatility and investment risk associated with CO_2 prices linked to oil prices; and
- Offering tax-exempt bonds and master limited partnership status to provide project financing on better terms.

Since the publication of this report, the 45Q tax credit has been increased and its lifetime extended which addresses the first point, however the remaining suggestions are unaddressed.

Review of Regulatory Developments

In contrast to the GCCSI report, some interviewees believed the responsibility for addressing gaps in legislation should lie with the federal government as opposed to states, with the suggestion to produce legislation which focuses on the whole lifecycle of CCS projects. A major area of concern is duplication and inconsistencies between regulations. This may be producing MRV plans for subpart RR in addition to plans required by the UIC regulations, or the more stringent monitoring requirements of the CA LCFS compared to the UIC Class VI well regulations. It is unlikely all the regulations and incentives will align due to their differing purposes. For example, the UIC aims to protect groundwater drinking water, it is not looking to incentivise CCS. CA LCFS is incentivising CCS but also wants to protect environmental integrity and reputation. The GHGRP and national inventory are more concerned with data quality and accountability, so have less focus on safety of the storage and are equally not looking to incentivise CCS.

The CA LCFS is an important milestone, providing a large incentive for companies which sell fuel in California. However, this is just one state, more regulations like this need to be implemented across more states, with many interviewees concerned the 45Q incentive is not sufficient. Despite this, the increase in the 45Q tax credit is a good step towards commercial scale deployment of CCS, but may not be enough to encourage this in some sectors including the oil and gas industry.

The view of interviewees is that there are advocates as well as opponents to CCS, and in general there is a low understanding of CCS in the USA, however this may not necessarily by problematic for deployment. Engaging the local community is important as projects move forward in order to gain support. There is a lack of Class VI permits, but interviewees believe this is not due to the length of

[19] Fourteen states now participate in the Work Group: Arkansas, Colorado, Indiana, Kansas, Kentucky, Mississippi, Montana, New Mexico, Ohio, Oklahoma, Pennsylvania, Texas, Utah and Wyoming

time the application takes, but rather from a lack of mechanisms to make money from CCS. There is a need for further economic and commercial drivers, opposed to improving the regulations.

3. CANADA

3.1 PAN-CANADIAN FRAMEWORK ON CLEAN GROWTH AND CLIMATE CHANGE

In 2016, the Canadian government in association with the eleven provinces, published the Pan-Canadian Framework on Clean Growth and Climate Change[20] The plan outlines steps for Canada to reach its emission reduction targets, grow the economy and build resilience to climate change.

As part of this, a wide range of policies were introduced, including carbon pollution pricing. By 2018 each Canadian Province must set their first annual price of carbon, at a minimum of CAN$10 per tonne of CO_2 rising to CAN$50 by 2022. All revenue will be returned to the province. If a province does not put a system in place, they must meet the federal standard. Provinces can choose between an explicitly price-based system i.e. a carbon tax or a cap-and-trade system. Guidelines in the framework include a gradual but predictable increase in carbon pricing which applies to a broad set of emission sources.

This scheme was planned to commence on 1st January 2019, however there has been no indication or announcement of this coming into force, or when this may occur instead.

If and when this carbon price commences, there is the expectation that the value of tonnes of CO_2 sequestered from CCS should be the value of carbon allowances avoided. However, there is currently no mechanism in place to explicitly allow this. Ultimately, a carbon price should help to incentivise low carbon technologies such as CCS.

3.2 BRITISH COLUMBIA LOW CARBON FUEL STANDARD

The British Columbia Low Carbon Fuel Standard (BC LCFS) is currently undergoing a consultation with stakeholders to update the existing regulations[21]. This includes:

- The feasibility of the carbon intensity targets, including the potential to require a 15 to 20 percent total reduction in carbon intensity of transportation fuels by 2030 (compared to 10% reduction in 2020 relative to 2010)
- Potential policy improvements requiring amendments to the Act and/or Regulation, including cost containment, refinery improvements, improvements to Part 3 Agreements, and recognition of Biojet fuel
- Amendments to the Act and Regulation to address issues that have been identified in the past few years that will require legislative and/or regulatory amendments

Pathway Assessment Document Review – Winter 17/18

In December 2017, a Pathway Assessment Document was released with a period allowing for written responses from stakeholders. This paper refers to CCS in two sections, the first of which is referencing CCS as a technology which could reduce the carbon intensity (CI) of ethanol. The second reference points to an example of where CCS is used in the production of biofuels, with CO_2 being sent to EOR operations. There is no reference to geological storage of carbon dioxide, only CCUS.

The industry comments include Northwest Redwater Partnership stating there is a lack of incentive to improve their carbon intensity. Husky comment that the consultations and publication of a new BC

[20] Government of Canada (2016) Pan-Canadian Framework on Clean Growth and Climate Change. Available online at: http://publications.gc.ca/collections/collection_2017/eccc/En4-294-2016-eng.pdf

[21] Government of British Columbia (2018) BC-LCFS Consultations. Available online at: https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/transportation-energies/renewable-low-carbon-fuels/bc-lcfs-consultations

LCFS should be stalled until the release of the federal regulation on clean fuel standards (see Sec 3.3).

The B.C. Ministry of Energy, Mines and Petroleum Resources confirmed they would not be waiting for the federal regulations due to delays in the federal process, and they commented they were as involved as they can be in the federal legislation development. In addition, the BC LCFS will be setting standards which are increasingly hard to reach each year, so waiting for the federal legislation to the published first would essentially forgo emission reductions in BC's view.

The toughening of BC LCFS standards each year going forward could provide additional incentives for CCUS.

Plans to include CCS in the BC LCFS

Currently, industry averages are used for crude products so as to not offer a competitive advantage dependent on resources available to certain companies. Every three years the BC LCFS undertakes a consultation which focuses on feasibility of pathways. The latest consultation in January 2017 commented on including refinery changes to reduce carbon intensity of fossil fuels, so BC LCFS is looking into gaining authority to approve this change, which would then give the ability for other changes to carbon intensity to be recognised including CCS. The internal process is underway to get this approval, and then a final public consultation would be required to make these changes. It is expected the final revision of the standard will be released in 2019.

It should be noted that the BC LCFS works in the same way as the CA LCFS in relation to production of the fuel; i.e., the lifecycle approach is applied to fuels sold in the Province regardless of where they are produced. Two-thirds of fuel consumed in BC is produced in Alberta. These fuels qualify for the BC LCFS.

Stakeholder and Consultation Process

The regular consultation processes allow the BC LCFS to maintain a transparent process. The Ministry acknowledged that a stakeholder concern is not officially required to get a change made to the standard, such as introducing CCS, but it will significantly help in elevating the process to Cabinet.

The Ministry understands that there are still public concerns relating to permanence of sequestration, while industry has concerns related to cost with a lack of incentives.

The BC LCFS already recognizes CCS in biofuel production, but does not currently have the authority to recognize it in fossil fuel production. The Ministry does follow what is happening in California and is aware of the California LCFS CCS Protocol.

Other Regulations in BC relevant to CCS

BC has appropriate regulations in place to govern oil and gas sourced acid-gas disposal. To address policy gaps for large scale geological CO_2 storage and eliminate regulatory uncertainty, the Ministry established an interagency team with the BC Oil and Gas Commission in consultation with the Climate Action Secretariat to develop a CCS regulatory policy framework (RPF). Industry and public consultation on the CCS RPF occurred between 2012 and 2014. The *Petroleum and Natural Gas Act* (*PNG Act*) was amended in 2015 to support implementation of the CCS RPF. Some further amendments will be required to fully implement the CCS RPF. The Ministry stated that British Columbia is aiming to have the cleanest and lowest carbon natural gas in the world; therefore it is looking to recognise technologies such as CCS which can lower the carbon intensity. This work is being undertaken by the oil and gas division of the Ministry of Energy and Mines.

3.3 CANADIAN FEDERAL CLEAN FUEL STANDARD[22]

In November 2016, the Government of Canada announced the beginning of a consultation process with provinces, territories, industries, NGOs and people to develop a clean fuel standard to reduce GHG emissions in Canada. The aim is to produce a performance-based approach which would incentivise low carbon fuels, energy sources and technologies. This standard would complement the pan-Canadian pricing on carbon pollution referred to in Section 3.1. It is hoped this standard can reduce GHG emissions by 30 megatonnes a year by 2030.

Consultations began in January 2017 with a committee and technical working group formed in December 2017. A discussion paper with stakeholder comments released in December 2017 stated that considerations should be taken to include the whole life cycle of fuels, to include emission reductions across the value chain including carbon capture technologies.

The current timeline for federal fuel quality standards is that regulations for liquid fuels will be published in 2020 coming into force by 2022, with regulations for gaseous and solid fuels release in 2021 and coming into force in 2023. Such standards could lead to discussions about emissions avoided by CCS, if the precedent of the CCS Protocol in California is deemed relevant.

3.4 ALBERTA CCS REGULATORY FRAMEWORK ASSESSMENT[23]

The Alberta CCS Regulatory Framework Assessment was undertaken from 2011 to 2013 in response to $1.3 billion investment in 2 commercial-scale CCS projects. More than 100 global experts on carbon capture and storage, including representatives from industry, environmental groups, scholars, and government worked on a review of existing regulations. The final report included over 70 conclusions and recommendations informing the ongoing development of the carbon capture and storage regulatory framework in Alberta. A selection of the key issues raised and the recommendations suggested are shown in Table 3.1. This process was undertaken to ensure the safest and most environmentally responsible regulatory environment for carbon capture and storage.

The Alberta Department of Energy continues to work on its response to the recommendations. Since the assessment, updates to the Mines and Minerals Act have been made which include:

- Transfer of most of the liabilities for a CCS project to the province once a closure certificate is issued
- Creation of a Post Closure Stewardship Fund to cover some liabilities with contributions to the fund coming from those projects injecting CO_2 under sequestration leases.

More recently, following the release of the Pan-Canadian Framework on Clean Growth and Climate Change, Alberta launched a $43.2 million Clean Technology Development Program to support and develop clean technologies. In addition, the $7 million Alberta Investor Tax Credit provides a 30% tax credit to encourage investment in clean technologies such as carbon capture technology [24]

[22] Government of Canada (2018) Clean Fuel Standard. Available online at: https://www.canada.ca/en/environment-climate-change/services/managing-pollution/energy-production/fuel-regulations/clean-fuel-standard.html

[23] Alberta Government (2013) Carbon Capture and Storage Summary Report of the Regulatory Framework Assessment. Available online at: https://open.alberta.ca/dataset/5483a064-1ec8-466e-a330-19d2253e5807/resource/ecab392b-4757-4351-a157-9d5aebedecd0/download/6259895-2013-carbon-capture-storage-summary-report.pdf

[24] Government of Canada (2018) Pan-Canadian Framework on Clean Growth and Climate Change. Second Annual Synthesis Report on the Status of Implementation – December 2018. Available online at: http://publications.gc.ca/collections/collection_2018/eccc/En1-77-2018-eng.pdf

Table 3.1 Alberta CCS Regulatory Framework Assessment: Gaps and Recommendations

Theme	Issues and Gaps	Recommendations
Applications, Approvals and Regulatory Framework	■ CCS projects do not currently require an Environmental Impact Assessment (EIA). ■ There are no industry-wide standards or limits on the level of impurities in CO_2 streams ■ CCS, CO_2-Enhanced Oil Recovery (CO_2-EOR), and Acid Gas Disposal (AGD) projects share many similarities and may overlap, but are subject to different regulatory frameworks	■ Require monitoring, measurement and verification (MMV) plans and closure plans to accompany all CCS related applications to the regulator and all tenure applications to the Department of Energy. ■ Consider subsurface CO_2 injection applications on a case-by-case basis, and give the regulator flexibility to determine the activities a proponent must undertake before approval. ■ Require CCS projects to report any production or atmospheric release of CO_2 and reconcile earned emission credits. ■ Clearly define how projects will be classified as CCS, CO_2-EOR or AGD, and the process for CO_2-EOR projects to become CCS projects. Evaluate if differences in the three regulatory frameworks are appropriate
Risks Assessment, Monitoring and Technical Requirements	■ CO_2 sequestration projects are not explicitly required to submit risk assessments or monitor effects beyond the injection site. ■ Current regulations do not include technical criteria for defining the capacity of a CO_2 sequestration site. ■ Existing requirements for evaluating and addressing legacy wells may not be sufficient.	■ Require MMV and closure plans to be based on a project-specific risk assessment, and include the use of best available technologies to monitor the atmosphere, surface, ground and surface water, and subsurface. ■ Require CO_2 sequestration sites to demonstrate sufficient capacity, injectivity, and containment parameters. ■ Evaluate if further research is needed on methods for detecting leaks from CO_2 pipelines.
Public Consultation and Notification, Surface Access and Public Safety	■ Current public consultation and notification requirements were not designed specifically for CCS. ■ It is unclear if CCS projects will require establishment of an emergency planning zone (EPZ). ■ Existing legislation does not explicitly allow applications for surface access to conduct monitoring activities beyond the surface lease site or by the Government of Alberta after the transfer of liability.	■ Review and update notification and consultation requirements to ensure that they are appropriate for CCS, including the requirement that everyone within the tenure boundary be informed about a CCS project. ■ Develop requirements for EPZs around CCS project infrastructure. ■ Improve public access to information on the regulatory process for CCS. Make pipeline integrity management plans available on request. ■ Clarify that CCS operators (including the Government of Alberta after transfer of liability) can apply for access to conduct MMV or reclamation activities over the entire area of their carbon sequestration lease.

Theme	Issues and Gaps	Recommendations
Site Closure and Long Term Liability	■ The Carbon Sequestration Tenure Regulation provides little detail on what a closure plan must contain. ■ The Mines and Minerals Act does not specify what performance criteria must be met to receive a closure certificate. ■ Assumed liabilities by the Government of Alberta do not include liability for CO_2 credits under climate change legislation.	■ Clarify the process for closing a CO_2 sequestration site and the information that closure plans must contain. ■ Establish performance criteria for closing a CO_2 sequestration site, including that the CO_2 is behaving as predicted, there are no significant risks to people or the environment, required closure activities have been carried out, and at least 10 years have passed since approval of the final closure plan. ■ Transfer liability for CO_2 credits to the Crown when a closure certificate is issued. ■ Set project-specific PCSF rates that cover the costs of long term monitoring and maintenance, CO_2 credits liability, and costs associated with unforeseen events. Pool PCSF payments to cover costs from any project. ■ Require operators to post financial security to pay for site closure and reclamation if they become defunct.

3.5 OTHER PROVINCE AND TERRITORY DEVELOPMENTS

CCS regulatory framework assessments have also been undertaken in British Columbia and Saskatchewan. The Natural Gas Development Statutes Amendments Act was passed in autumn 2015 in British Columbia which included amendments to the Petroleum and Natural Gas Act and the Oil and gas Activities Act to enable CCS [25].Saskatchewan Oil and Gas Conservation Regulation came into force in 2012 as part of the amended Saskatchewan Oil and Gas Conservation Act, enabling greater oversight for CO_2 storage.

In 2016, Quebec and Saskatchewan announced a collaboration to further develop CCS technology[26]. This will include exchanging updates and information on CCS projects and technologies and working together to explore opportunities of further collaborations notably with the recent SaskPower CCS Knowledge Centre.

In Quebec, a $15 million budget across three years has been allocated to the creation of Valorisation Carbone Québec valuation consortium which brings together public and private sector organisations specialising in CCS. Its aim is to capture and utilise CO_2 in applications crucial to their economy such as the conversion of biofuels, production of reinforced concrete and EOR. As of April 2018, eleven organisations have confirmed their participation in the consortium [27]

The Carbon Capture and Storage Research Consortium of Nova Scotia (CCSNS) is a non-profit organisation which was incorporated in 2008. Three phases of work[28] have been identified to deploy CCS on a commercial scale. These are:

1. Research in technical and preliminary economic feasibility of applying CCS in Nova Scotia (2009-2015)
2. Pilot plant and injection phase based on findings from Phase 1 research (2015-2018)
3. Commercial scale operation based on Phase 2 findings (2018-2025)

3.6 GAP ANALYSIS AND SUMMARY - CANADA

Stakeholders involved in development of regulations which include CCS in British Columbia and Canada on a wider scale have commented there is a need for larger incentives. The mandatory carbon pollution pricing as part of the Pan-Canadian Framework on Clean Growth and Climate Change should help to incentivise low carbon technologies such as CCS. However, the implementation varies considerably between provinces and territories and there is currently no system in place for avoided emissions from CCS.

Schemes vary across Canada from a basic carbon tax to a cap and trade system, all of which have varying boundaries for which companies and industries are included, in addition to varying levels of ambition. There is also variation across Canada in relation to regulations relating to CCS. Some provinces and territories undertook a CCS regulatory framework assessment which has enabled

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[25] Government of British Columbia (N.D.) Carbon Capture and Storage Regulatory Policy Framework. Available online at: https://www2.gov.bc.ca/gov/content/industry/natural-gas-oil/responsible-oil-gas-development/carbon-capture-storage/ccs-reg-framework

[26] Government of Saskatchewan (2016) Québec and Saskatchewan Join Forces in the Development of Research and Technologies Related to Carbon Capture and Storage. Available online at: https://www.saskatchewan.ca/government/news-and-media/2016/june/16/quebec-saskatchewan-mou

[27] Carbon Capture Journal (2018) Total joins CO2 Solutions' Valorisation Carbone Québec project. Available online at: http://www.carboncapturejournal.com/news/total-joins-co2-solutions-valorisation-carbone-qubec-project/4024.aspx?Category=all

[28] Carbon Capture and Storage Research Consortium of Nova Scotia (CCSNS) (2015) CCS Nova Scotia: Executive Summary. Available online at: https://www.nspower.ca/site/media/Parent/CCSNS%20Geological%20Research%20-Executive%20Summary%20-April%202015.pdf

improvements to their regulations. Alberta's assessment was very detailed, enlisting a committee of technical experts. The resulting regulations are considered some of the most robust to date by interviewees. However, these are not standalone regulations, but are embedded within the wider act relating to industries such as oil or natural gas. This could be problematic for companies which work across provincial borders, having different regulations to comply with.

The BC LCFS does not currently include CCS in the pathway assessments for calculating carbon intensity for fuels, due to a request made by industry approximately ten years ago. CCUS in relation to biofuels however is included. Following recent requests from industry, the need to consider CCS is being reassessed and the BC LCFS program is seeking approval from the Cabinet to assess the inclusion of CCS in the BC LCFS. In addition, British Columbia are in initial discussions to introduce new regulations for using CCS to lower carbon intensity in the natural gas industry.

Finally, a range of provinces and territories have taken further steps to incentivise CCS technology. Alberta has created a $43.2 million Clean Technology Development Programme, with a further $7m in tax credits which will incentivise low carbon technologies such as CCS. Quebec has also budgeted $15 million for Valorisation Carbone Québec, which is a project to aid the development of CCUS. Overall there is quite a considerable amount of regulatory development in Canada.

4. EUROPE

4.1 EU CCS DIRECTIVE

The EU CCS Directive[29] was introduced in 2009, with a deadline of 2011 for EU member states to transpose the Directive into national law. Previous CO_2 Capture Project reports have commented on the technical content, but a summary of the regulation is given for context in Box 4.1. The key points can also be found in Table 9.1, compared to other regulations such as the Class VI well permits in the USA. It should be noted that the EU CCS Directive is not transposed identically across EU member states. This is explained in more detail in section 4.1.2.

European Commission CCS Permit Review

One key area of conformance is the requirements for a review of CCS permits by the European Commission. The European Commission have reserved the right to review permits issued by EU Member States for CCS projects and to issue a non-binding 'opinion' on the extent to which the CCS regulatory requirements imposed by the Member State are deemed by the Commission to conform to EU requirements. If, in the opinion of the EC, the proposed Member State project permit deviates in any respect(s) from EU requirements, the national government must explain why to the Commission. This is designed to ensure consistency in implementation across member states.

The EU review is based in particular on Articles 8 ("conditions for storage permits") and 9 ("contents of storage permits") of the CCS Directive. The review should also cover the proposed monitoring plan (Article 9, point 5, of the CCS Directive), the proposed corrective measures plan including the risk management plan (Article 9, point 6, of the CCS Directive), and the provisional post-closure plan (Article 9, point 7, of the CCS Directive).

Should the Commission decide to review the draft Member State permit for a CCS project, they will be looking both for completeness (i.e., that all key aspects of EU requirements have been addressed) and conformance (i.e., that the manner the permit deals with key aspects conforms to EU Guidance). The Commission's opinion will be made public, along with the response from the Member State authority, allowing stakeholders to view the adequacy of the CCS project permit and apply pressure to the operator to make the suggested changes highlighted by the Commission.

Box 5 Key Regulatory Requirements of the EU CCS Directive

- The Directive does not apply to total intended storage below 100 kilotonnes for projects undertaken for research, development or testing new processes
- During the early phase of implementation, to ensure consistency, all storage permit applications should be made available to the Commission after receipt. The Commission will issue an opinion on the draft permit within four months, which national authorities should take into consideration when making their decision. Any departure from the Commission's opinion should be justified.
- Monitoring is essential to assess whether injected CO_2 is behaving as expected, whether any migration or leakage occurs, and whether any identified leakage is damaging the environment or human health. Member States should ensure that during the operational phase, the operator monitors the storage complex and the injection facilities on the basis of a monitoring plan designed pursuant to specific monitoring requirements. The plan should be submitted to and approved by the competent authority
- The operator should report the results of the monitoring to the competent authority at least once a year.
- Liability for climate damage as a result of leakages requires surrender of emissions trading allowances for any leaked emissions

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[29] Official Journal of the European Union (2009) DIRECTIVE 2009/31/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006. Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0031&from=EN

- The operator is obliged to take corrective measures in case of leakages or significant irregularities on the basis of a corrective measures plan submitted to and approved by the competent national authority. Where the operator fails to take the necessary corrective measures, these measures should be taken by the competent authority, which should recover the costs from the operator.
- After a storage site has been closed, the operator should remain responsible for maintenance, monitoring and control, reporting, and corrective measures on the basis of a post-closure plan submitted to and approved by the competent authority
- The operator shall also be responsible for sealing the storage site and removing the injection facilities
- The responsibility for the storage site, including specific legal obligations, should be transferred to the competent authority, if and when a) all available evidence indicates that the stored CO_2 will be completely and permanently contained b) a minimum period, to be determined by the competent authority has elapsed. This minimum period shall be no shorter than 20 years, unless the competent authority is convinced that the criterion referred to in point (a) is complied with before the end of that period; c) the financial obligations have been fulfilled; d) the site has been sealed and the injection facilities have been removed.
- After the transfer of responsibility, monitoring should be reduced to a level which still allows for identification of leakages or significant irregularities, but should again be intensified if leakages or significant irregularities are identified. There should be no recovery of costs incurred by the competent authority from the former operator after the transfer of responsibility except in the case of fault on the part of the operator prior to the transfer of responsibility for the storage site.
- Financial provision should be made in order to ensure that closure and post-closure obligations under this Directive to take corrective measures in case of leakages or significant irregularities, can be met. Member States should ensure that financial provision, by way of financial security or any other equivalent, is made by the potential operator so that it is valid and effective before commencement of injection
- Member States shall take the necessary measures to ensure that potential users are able to obtain access to transport networks and to storage sites for the purposes of geological storage of the produced and captured CO_2. The access shall be provided in a transparent and non-discriminatory manner determined by the Member State

4.1.2 Implementation Report for the EU CCS Directive

The second report on implementation of the EU Directive on the geological storage of carbon dioxide was published by the European Commission in 2017[30], covering the period from May 2013-April 2016[31] using reports submitted by 26 member states. To date, the Commission believes legislation of 16 member states is fully conforming to the EU CCS Directive.

Storage

Since the previous reporting period in 2013, Member States have generally not determined any new areas from which storage sites may or may not be selected. Only Poland has determined one storage area. Member States intending to allow storage in their territory must undertake assessments of their storage capacity. New assessments of available storage have been carried out, are ongoing or are planned in: Bulgaria, Germany, Greece, Hungary, Italy, the Netherlands, Sweden and the United Kingdom. In contrast, five German federal states have passed laws limiting underground storage of CO_2 including for research purposes, thus discouraging CCS projects.

[30] European Commission (2017) Report from the Commission to the European Parliament and the Council on Implementation of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide. Available online at: https://ec.europa.eu/clima/sites/clima/files/docs/pages/com20017_37_ccs_directive_implementation_report_en.docx

[31] This time period was chosen by the EC and is based upon the time period covered in reports from the member states.

Permits

Only Spain has applied for exploration permits; these were reviewed by the European Commission and an 'opinion' was issued per the review process described above. The Peterhead CCS project in the UK applied for a storage permit, but this project did not go ahead. At the time of publication, an application for a storage permit has been received in Italy.

Retrofitting

The CCS Directive requires that when applying for licence for new large scale combustion plants, operators must assess the technical and economic feasibility of carbon capture, transport and storage. If the assessment is positive, space on the installation site must be set aside for the equipment necessary to capture and compress CO_2. Assessments have been undertaken by operators in Belgium (one), Czech Republic (one), Germany (five), Romania (six), Poland (ten), Slovenia (one) and Spain (five). Assessments found CCS to not be economically feasible, and some further difficulties were encountered including no suitable storage sites. Nevertheless, many sites are setting aside land so the CO_2 separation equipment could be retrofitted at a later date, which is in line with the capture ready concept.

In the UK, national legislation exceeds the requirements of the Directive, granting permission to power plants only if they can prove they will meet the CCS feasibility conditions during the life-time of the power stations. This shows the ambition of the UK government for CCS to be successful. Fourteen permits for new large scale power plants have been approved in UK between May 2013 and April 2016, with economic assessments showing CCS is feasible and could be retrofitted to the power plants if the carbon price is appropriate.

CO_2 Transport and Storage Networks

Two CCS regional networks are being developed to have common, transboundary solutions for transport and geologic storage of CO_2. These groups are:

- North Sea Basin Task Force: UK, the Netherlands, Norway, Germany and Belgium
- Baltic Sea Region CCS Network: Estonia, Germany, Finland, Norway and Sweden

The aim is for these networks to facilitate transparent access to a CO_2 transport network and CO_2 storage sites for EU member states where they have no options for underground storage. However, this will be problematic in some instances due to the insufficient ratification of the 2009 amendment to the London Protocol (see Section 8.1).

Overall, the EU reports that the CCS Directive has been consistently applied across EU member states and some member states are making progress with their assessment into storage capacity. Conversely, the GCCSI legal and regulatory indicator[32] results suggest there is considerable disparity between EU member states. Croatia, Czech Republic, Hungary, Malta and Iceland have seen their scores improve due to improving domestic implementation of the EU Directive on CCS. Conversely, Estonia's score has decreased due to a softening of their approach to liability. This is due to the wider range of criteria that the GCCSI uses as part of its assessment, which includes public engagement and other national planning legislation in place.

[32] Global CCS Institute (2018) CCS Legal and Regulatory Indicator (CCS-LRI). Available online at: http://decarboni.se/sites/default/files/publications/202111/ccs-legal-and-regulatory-indicatorglobal-ccs-institute-2018digital.pdf

4.2 EUROPEAN UNION EMISSION TRADING SYSTEM (EU ETS)[33]

The European Union Emission Trading System (EU ETS) was the first large GHG emission trading scheme in the world. It is a cap and trade system, setting a cap on the system-wide level of GHGs emitted by operators covered by the system. Allowances for emissions can be traded, and there is a limit, which ensures they have a value. Each year companies surrender allowances to cover their emissions. The lower the emissions, or if emissions can be avoided, then the less allowances which need to be purchased.

As part of the latest amendments to the Directive for the EU ETS, which occurred in March 2018, the European Commission have developed an Innovation Fund that will launch in 2021. 450 million EU allowances have been put aside to support low-carbon technologies including carbon capture and utilisation as well as products substituting carbon intensive ones. The fund is also available to help stimulate the construction and operation of CCS projects as well as innovative renewable energy and energy storage technologies. Projects in all EU member states including small-scale projects are eligible for the new fund. 50 million of those allowances are to be allocated to supplement any available revenues from the 300 million allowances available in the period 2013 and 2020, which shall be used for innovation support.

Projects involving CCUS must ensure avoidance or permanent storage of CO_2 and deliver a net reduction in emissions. Technologies should not yet be commercially available but shall represent new solutions or be sufficiently mature for demonstration or pre-commercial scale projects. The innovation fund can support up to 60% of the project costs, of which 40% need to be dependent on verified avoided GHG emissions provided at pre-determined milestones.

A report conducted by the European Court of Auditors[34] concluded that EU action to support carbon capture and storage, in addition to innovative renewables in the past had not succeeded. The report focused on two large funding programmes launched in 2009 to support both these technologies: the European Energy Programme for Recovery and the New Entrants' Reserve 300 programme. This represented a spending budget of €3.7 billion. They found that the Energy Programme for Recovery fell short of its ambitions for carbon capture despite having positively contributed to offshore wind development. Moreover, the New Entrants' Reserve programme delivered no successful carbon-storage projects.

The reason for the failure of these schemes was noted by the auditors as "adverse investment conditions". This included uncertainty in regulatory frameworks and policies delaying project development, in addition to lower than expected carbon market prices after 2011 being the key reason for failure of carbon capture and storage deployment. Ahead of the Innovation Fund launching, the auditors have made the following recommendations to the European commissions:

- Increase the potential for effective EU support for such projects;
- Improve the project selection and decision-making procedures for the forthcoming Innovation Fund, and ensure its flexibility to respond to external developments;
- Enhance its internal coordination for more coherent targeting of EU support;
- Ensure accountability for the Innovation Fund and the New Entrants' Reserve Programme.

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[33] European Parliament (2018) DIRECTIVE 2003/87/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 13 October 2003 establishing a M9 system for greenhouse gas emission allowance trading within the M9 Union and amending Council Directive 96/61/EC text with EEA relevance of 14 March 2018. Available online at: https://eur-lex.europa.eu/eli/dir/2003/87

[34] European Court of Auditors (2018) Special Report – Demonstrating carbon capture and storage and innovative renewables at commercial scale in the EU: intended progress not achieved in the past decade. Available online at: https://www.eca.europa.eu/Lists/ECADocuments/SR18_24/SR_CCS_EN.pdf

4.3 EU FUEL QUALITY DIRECTIVE[35]

The EU Fuel Quality Directive requires a reduction in the greenhouse gas intensity of transport fuels by a minimum of 6% by 2020. It applies to petrol, diesel and biofuels used in road transport and gasoil used in non-road-mobile machinery. The greenhouse gas intensity is calculated based on the full lifecycle, including extraction, processing and distribution.

The Fuel Quality Directive was produced in 1998 and has since been amended 7 times. The Amendments in 2009 included the acknowledgement of CCS as a technology for reducing GHG emissions per unit of energy from fuel or energy supplied during the product's lifecycle.

Default values of GHG emission savings are provided for common biofuel production pathways to "avoid disproportionate administrative burden". The data used in these calculations is obtained from independent, scientifically expert sources. Following this, in 2015, amendments were introduced to establish GHG emission default values for the use of CCUS for transport fuel purposes.

4.4 EU SUMMARY

The EU has implemented a range of different regulations and incentives for CCS. The EU CCS Directive applies to all operations storing more than 100 kilotonnes. To date, 16 member states have national legislation which is fully conforming to the CCS Directive. Progress since 2013 has been slower, with only one new storage location identified in individual country assessments between 2013 and 2016. Evaluations of the feasibility of adding CCS to new scale combustion plants across a range of member states has concluded CCS is not economically feasible, but many are putting land aside should this change, in line with the capture ready concept. The UK is being more ambitious, only granting permissions to go ahead with power plant construction if operators can prove they will meet CCS feasibility during the facility's lifetime.

In order to promote CCS and improve collaboration, two regional CCS networks have been created: the North Sea Basin Task Force and the Baltic Sea Region network. The aim is to allow transparent access to CO_2 transport and storage sites. However, due to insufficient ratification of the London Protocol, transboundary transfer of CO_2 for offshore sub-surface storage is not allowed which could be problematic.

The EU ETS is taking steps to incentivise CCS with the supply of 450 million allowances into the Innovation Fund for low carbon technologies. However, reports by the European Court of Auditors concluded previous EU support for CCS had not been sufficient due to lower than expected carbon pricing and regulatory uncertainty. The auditors have released recommendations ahead of the Innovation Fund launching.

The European Union is responsible for one of the earliest fuel quality regulations which includes CCS, with an amendment to the European Fuel Quality Directive in 2009. From 2015, CCUS included in transport fuels is also recognised for calculating GHG lifecycle emissions of fuels.

The EU reports consistent implementation of the CCS Directive across EU member states with progress being made with assessing storage capacity. In contrast the GCCSI legal and regulatory indicator which evaluates the regulatory landscape on a wider scale, considering more factors, comments there is considerable disparity between EU member states. Further regulations, incentives and developments in some member states are discussed below in sections 4.5 to 4.7.

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[35] European Parliament (2009) DIRECTIVE 2009/30/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC. Available online at: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32009L0030

4.5 UK

The UK Government transposed the EU CCS Directive into the UK Energy Act. In addition to these regulations, the UK has taken further steps towards commercial deployment of CCS. Unfortunately, the UK cancelled its £1billion CCS grant programme in November 2015, but has since then renewed its focus on CCS with the UK Clean Growth Strategy and associated advancements in regulation and policy.

4.5.1 UK Clean Growth Strategy[36]

The UK Clean Growth strategy was released in October 2017 stating renewed ambition by the UK to deploy CCUS in scale during the 2030s, albeit subject to cost reducing sufficiently. As part of this strategy it included a goal to "demonstrate international leadership in carbon capture usage and storage by collaborating with our global partners and investing up to £100 million in leading edge CCUS and industrial motivation to drive down costs". This will include £20 million for a carbon capture and utilisation demonstration programme to invest in new innovative technologies. Although this total is 10% the value of the original grant, it is still a sizeable commitment to CCS development. The document comments on CCUS extensively, including covering some of the possible issues such as a lack of technology advancement and high costs. However, the strategy states there is the opportunity for the UK to become a "global technology leader for CCUS", working internationally with industries and governments to bring around global cost reductions through a range of steps:

1. Re-affirming the commitment to deploying CCUS in the UK, subject to cost reduction
2. International collaboration
3. Innovation

To meet Step 1 of the above, a CCUS Cost Challenge Taskforce will be produced to deliver a plan to reduce the cost of deployment, which will result in a deployment pathway in 2018. In addition, a CCUS Council would be produced, to work with industry to deploy and maximise opportunities.

Step 2 involves continuing the UK £60 million international CCS programme which began in 2012, aiming to invest a further £10 million, in addition to organising a global conference in 2018 with international partners. This was held in Edinburgh in November 2018.

Step 3 refers to the £100 million budget from the BEIS Energy innovation programme to support CCUS innovation and deployment in the UK.

4.5.2 Delivering Clean Growth[37]

The CCUS Cost Challenge Taskforce was established in January 2018 and they published a report Delivering Clean Growth in July 2018. This concludes that CCUS meets the three tests of the clean growth strategy which are:

- Delivering maximum carbon emission reductions
- Following a clear cost reduction pathway
- Making the UK a global technology leader

However, the Taskforce has four main messages to government which are:

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36 UK Government (2017) The Clean Growth Strategy. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf

37 CCUS Cost Challenge Taskforce (2018) Delivering Clean Growth. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/727040/CCUS_Cost_Challenge_Taskforce_Report.pdf

- There is an urgency to recognise the CCUS opportunity and act now in order to deliver CCUS at scale.
- CCUS can unlock value across the economy, for industry, electricity, hydrogen, GHG removal and new industries
- CCUS needs viable business models to move the technology along in a viable way
- The taskforce believe CCUS can already be deployed at a competitive cost, recommending a cluster technique for deployment.

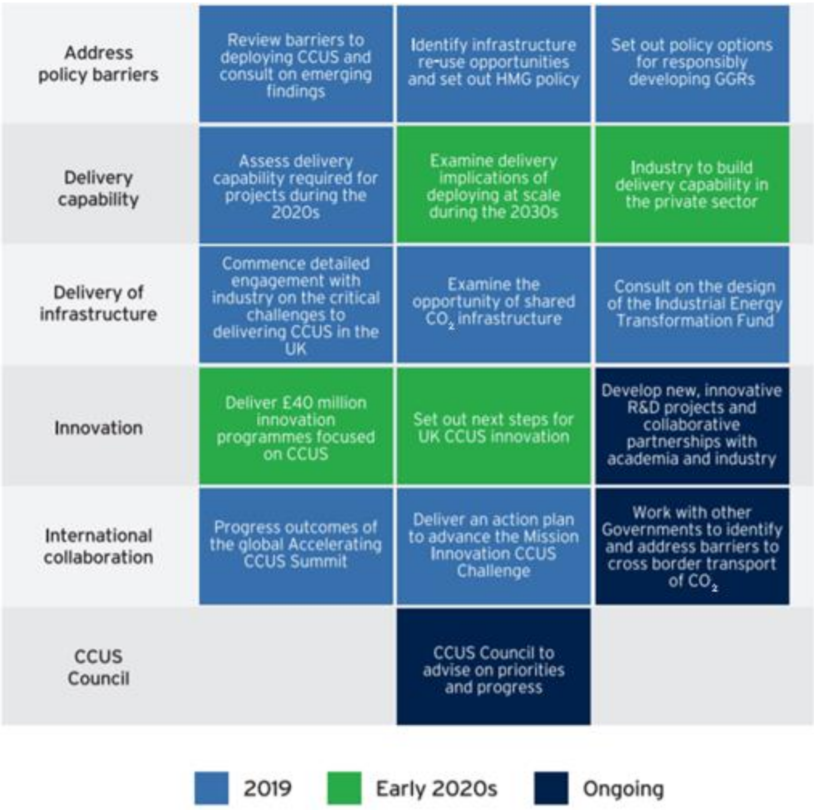
At the top of the Taskforce's recommendations was the priority to publish the CCUS Deployment Pathway before 2018 (this was done in November 2018-see next section). In addition, they prioritised a policy framework and criteria to enable and prioritise CCUS clusters in the first half of 2019.

4.5.3 The UK CCUS Deployment Pathway: An Action Plan[38]

In November 2018, the UK government published an action plan on the UK CCUS development pathway. The action plan is designed to enable development of the first CCUS facility in the UK, commissioning from the mid-2020s in line with the goal of deploying CCUS at scale in the 2030s subject to costs coming down sufficiently.

The report states that in 2019 the government will engage with industry on the challenges, and the first CCUS facility will need to demonstrate that the technology is cost effective. The actions required to reach the 2030 goal are shown in Figure 4.1. These are split into goals for 2019, early 2020s and ongoing goals.

Figure 4.1 Summary of Actions Needed to Deliver the UK Clean Growth Strategy 2030 Ambitions for CCUS



Address policy barriers	Review barriers to deploying CCUS and consult on emerging findings	Identify infrastructure re-use opportunities and set out HMG policy	Set out policy options for responsibly developing GGRs
Delivery capability	Assess delivery capability required for projects during the 2020s	Examine delivery implications of deploying at scale during the 2030s	Industry to build delivery capability in the private sector
Delivery of infrastructure	Commence detailed engagement with industry on the critical challenges to delivering CCUS in the UK	Examine the opportunity of shared CO_2 infrastructure	Consult on the design of the Industrial Energy Transformation Fund
Innovation	Deliver £40 million innovation programmes focused on CCUS	Set out next steps for UK CCUS innovation	Develop new, innovative R&D projects and collaborative partnerships with academia and industry
International collaboration	Progress outcomes of the global Accelerating CCUS Summit	Deliver an action plan to advance the Mission Innovation CCUS Challenge	Work with other Governments to identify and address barriers to cross border transport of CO_2
CCUS Council		CCUS Council to advise on priorities and progress	

38 UK Government (2018) Clean Growth: The UK Carbon Capture Usage and Storage deployment pathway. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/759637/beis-ccus-action-plan.pdf

The report comments it will progress CCUS through a staged process which will allow regulatory concepts to be developed and tested incrementally through the 2020s. A range of possible regulatory mechanisms and incentives have been considered, which are shown in Figure 4.2.

Figure 4.2 Regulatory Mechanisms for CCUS Deployment in the UK

Option	Description
Contract for Difference on CO_2 abatement strike price	Strike price per tonne of CO_2 abated on CO_2 certificate value, contractually agreed in advance to cover expected industrial carbon capture costs relative to business as usual.
Cost-plus open book	Emitter is directly compensated for all properly incurred operational costs through Government grant funding.
Regulated Asset Base (Hydrogen only)	Product price (Hydrogen) regulated to recover capital and operational costs.
Tradeable tax credits	Reductions in tax liability of energy intensive industries with industrial carbon capture, in £/tCO_2 abated. The tax credits may be fixed or may taper down over time. Tradeable to allow realisation of their full value.
Tradeable CCUS certificates, plus obligation	CCUS certificates are awarded per tonne of CO_2 abated and can be sold to other obligated emitters. There are obligations on emitters and/or fuel suppliers to present the required number of certificates.
Low carbon market creation	Creation of a low-carbon market through certification, public procurement and end-use regulations, allowing a price premium for low carbon goods.

The UK government also acknowledges the need for regulatory coherence, aiming to work with sectors to ensure this happens.

More recently, the UK Oil and Gas Authority has awarded the first CCS license[39]. This grants authorisation for offshore exploration for the purposes of selecting a site for CO_2 storage. Under the terms of the licence, the company would need to submit and be awarded a Storage Permit before CO_2 injection could begin.

4.6 NETHERLANDS

The Netherlands regulatory environment for CCS has been in flux. The EU CCS Directive has been transposed into the Dutch national Mining Act law. But, in 2017, the largest European CCS project, "ROAD", based in the Netherlands was cancelled. Since then the Netherlands announced new climate targets with an increased role for CCS in 2017, aiming to reduce emissions by 20 million tonnes a year by 2030. This was part of the Dutch Coalition Agreement.[40] In addition, in April 2018 a

[39] Carbon Capture Journal (2018) UK Oil and Gas Authority awards first CCS license to Acorn project. Available online at: http://www.carboncapturejournal.com/ViewNews.aspx?NewsID=4106

[40] Government of the Netherland (2017) Confidence in the Future 2017-2021 Coalition Agreement. Available online at: https://www.government.nl/binaries/government/documents/publications/2017/10/10/coalition-agreement-confidence-in-the-future/coalition-agreement-2017-confidence-in-the-future.pdf

study into the feasibility of CCS in the Port of Rotterdam found that CO_2 capture, transport and storage under the North Sea is technically feasible and cost-effective.

The Dutch Coalition Agreement

The leaders of four parties of the Dutch parliament presented this new coalition Agreement in October 2017. This includes an aim to reduce GHG emissions by 49% by 2030, the equivalent of 56 Mt CO_2e. 18Mt and 2Mt of savings are expected to come from CCS used in industry and electricity generation respectively.

Further sections of the agreement include details on adjusting the energy tax regime, with taxes on gas and electricity consumption being more in keeping with carbon emissions. This will be supported by the introduction of a minimum carbon price for the electricity sector, which will create incentives for energy savings and emission reduction. The aim is to move towards a green tax system for individuals and businesses.

Finally, €300 million a year is also being set aside for government to jointly explore how policy can be designed successfully, how to develop expertise and what pilot projects could be carried out as part of the section on financing the climate and energy transitions.

4.7 NORWAY

There has been an active CCS programme in Norway for many years. The Norwegian offshore projects Sleipner and Snøhvit are Europe's only large-scale CCS projects in operation. Since 1996, about 1 million tonnes of CO_2 per year have been separated during processing of natural gas from the Sleipner Vest field and stored in a saline aquifer in the subsea Utsira Formation. The Snøvhit facility on Melkøya separates CO_2 from the well stream before the gas is chilled to produce liquefied natural gas (LNG) and has been doing so since 2008. The CO_2 is transported back to that field, injected and stored. Since 2014, CO_2 has also been separated from natural gas from the Gudrun field and stored in the same Utsira Formation.

A key incentive to avoid offshore CO_2 emissions in Norway is the tax on those emissions. For 2019, the emissions tax rate is equivalent to NOK462 per tonne of CO_2. Storing CO_2 via CCS avoids that tax.

The current government[41] has made CCS one of five prioritized areas for national climate action. Their ambition is to realise a cost-effective solution for full scale CCS in Norway, provided this will result in technology development internationally. A July 2016 feasibility study showed that realising a full-scale CCS chain in Norway by 2022 is possible at lower costs than for projects considered in Norway earlier.

The government decided in May 2018 to fund FEED studies for the 'Northern Lights' project with CO_2 capture at Norcem's cement plant in Brevik and Fortum Oslo Varme's waste incineration plant in Oslo. They dropped previous support for capturing emissions from a Yara chemical plant producing ammonia.

The plan is for CO_2 to be transported by ships from the two capture facilities, both in the eastern part of Norway, to an onshore facility on the west coast of Norway. Transport of CO_2 by ship would allow other sources of CO_2 to use the storage infrastructure. After intermediate onshore storage, the CO_2 is to be piped out for permanent storage in a geological formation far below the seabed in the North Sea. Equinor, with partners Shell and Total, lead the planning for the offshore storage part of the project.

Ministry of Petroleum and Energy permits for offshore CO_2 storage follow project development steps:

[41] Norwegian Government (2019) Carbon capture and storage – CCS. Available online at: https://www.regjeringen.no/en/topics/energy/carbon-capture-and-storage/id86982/

- ‘screening permit’ for initial storage site characterization
- ‘exploration’ permit for more detailed storage site assessment
- ‘exploitation’ permit for saline aquifer utilisation by the CO_2 storage project

The National Environment Agency issues an ‘injection and monitoring’ permit for storage site operation. Other regulations apply in the construction phase and safety regulations continue throughout operation.

On 11 January 2019, Equinor received an ‘exploitation’ permit for CO_2 storage on the Norwegian Continental Shelf. The allocated area for storing CO_2 is located close to the Troll field in the North Sea. The storage is a key element of the planned full-scale project with capture, transport and storage of CO_2.

The 2019 Norwegian budget proposed about NOK 670 million for CCS, an increase of more than NOK 160 million compared to the final budget for 2018. The 2019 budget proposal includes funds for work on the Northern Lights project. The Government also increased funding for Technology Centre Mongstad[42].

Assessment of FEED study results for the ‘Northern Lights’ project will be carried out before the Government concludes whether the project should be realised. An investment decision may be taken in 2020/2021. Norway is expected to request financial support from the EU Innovation fund (see section 4.2) as a key factor in the investment decision. Operations under the Northern Lights CCS project could begin in 2023/24 if final investment is approved and project completion is as planned[43].

4.8 GAP ANALYSIS AND SUMMARY - EU

Despite the UK cancelling their $1 billion CCS grant programme in November 2015, they have renewed their CCS ambitions with the Clean Growth Strategy which was published in October 2017. The aim is to deploy CCUS at scale by 2030. As part of this process, the CCUS Cost Challenge Taskforce was created. Their report “Delivering Clean Growth” published in July 2018 concludes that CCUS meets the three tests of the Clean Growth Strategy. The report urges the UK government to recognise the CCUS opportunity and act now to deliver CCUS at scale. The taskforce also believe CCUS can already be deployed at a competitive cost, recommending a cluster technique for deployment. In November 2018, the UK produced a deployment plan, with deployment at scale in 2030s, with commissioning commencing in mid-2020s. A wide range of regulatory mechanisms and incentives are being considered including tradeable tax credits, or tradeable CCUS certificates.

The Netherlands cancelled the largest European CCS project “ROAD” in 2017 but have since announced new climate targets with an increased role for CCS, reducing emissions by 20 million tonnes CO_2 a year by 2030. A feasibility assessment of CCS in the port of Rotterdam under the North Sea has shown to be technically feasible and cost effective. As part of the Coalition Agreement, the Dutch Government aims to adjust energy tax so it is more in keeping with carbon emissions. Finally €300 million budget has been assigned for policy and expertise development for climate and energy transition including CCS.

Norway is currently the only country which has an active CCS programme in Europe. They have a carbon tax which applies to sources of offshore emissions, for which storing CO_2 via CCS offshore avoids this tax, acting as an incentive for deployment. There has been considerable funding dedicated to CCS in Norway, with NOK 670 million in 2019, which includes budget for the FEED study of the “Northern Lights” project. This project would commence operation in 2023/4 if investment is approved and the FEED study results are positive. In addition, Norway is expected to request financial support from the EU Innovation fund for the “Northern Lights” project.

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[42] Carbon Capture Journal (2018) Norway’s increased efforts on carbon capture and storage. Available online at: http://www.carboncapturejournal.com/news/norways-increased-efforts-on-carbon-capture-and-storage/4075.aspx?Category=all

[43] Gassnova (2019) Available online at: http://www.gassnova.no/en/

The UK, Norway and the Netherlands have recently invested or budgeted money for CCS or CCUS development in their countries, although they have taken differing approaches to this. The UK claims CCUS is not currently economically feasible but the experts of the CCUS Cost Challenge Taskforce disagree, whereas the Netherlands believe CCS is feasible, and Norway is already actively undertaking CCS. In general, all three countries are developing plans for the future and are some of the most progressive European countries relating to CCS.

5. AUSTRALIA

5.1 FEDERAL REGULATIONS

In order to ensure consistent regulations for CCS activities across Australia and its jurisdictions, the Australian Regulatory Guiding Principles[44] were introduced in 2005. This focuses on six fundamental issues:

1. Assessment and approvals processes
2. Access and property rights
3. Transportation issues
4. Monitoring and verification
5. Liability and post-closure responsibilities
6. Financial issues

These guidelines are not legally binding, but have been considered by both state and commonwealth governments in designing regulatory frameworks.

In 2008, the Australian Commonwealth[45] Government passed the Offshore Petroleum Amendment (Greenhouse Gas Storage) Act 2008[46]. This is the regulations for CO_2 storage in federal offshore waters, which do not fall under state jurisdiction, which control the first three nautical miles from the coast. The main points of the regulation are explained in Box 5.1.

It is worth noting there are no conditions in the regulations for an EIA prior to the granting of a GHG assessment permit (step 2) or a GHG injection license (step 5). However, an EIA is required to be incorporated in an 'environment plan' for activities under the permit, which must be approved by the Minister of the Commonwealth before the activities can commence. The Minister also has broad discretion to impose "whatever conditions [the Minister] thinks appropriate" which could include environmental conditions.

Federal legislation focuses only on offshore storage of CO_2, however a couple of states have introduced onshore regulations (see sections 5.2 - 5.4).

In 2012, Australia introduced a carbon tax for facilities emitting more than 25,000 tonnes of carbon dioxide equivalent a year. This would transition to a cap and trade scheme in 2015. However, in 2014 this was repealed due to claims the cost was being passed onto consumers and increasing the cost of living.

Box 6 Overview of the Australian Federal Offshore CCS Regulation

There are six main steps to being granted approval for offshore storage.

1. Release of acreage for exploration of potential storage formations by the Commonwealth Minister.

- First release of acreage occurred on 27th March 2009. At least ten have been released.

2. Application for a GHG assessment permit

- Must detail proposal for work and expenditure, applicant’s technical qualification, available financial resources

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[44] Ministerial Council on Mineral and Petroleum Resources (2005) Australian Regulatory Guiding Principles. Available online at: https://www.industry.gov.au/sites/default/files/July%202018/document/pdf/regulatory-guiding-principles-carbon-dioxide-capture-and-geological-storage.pdf

[45] The Federal government in Australia

[46] Federal Register of Legislation (2008) Offshore Petroleum Amendment (Greenhouse Gas storage) Act 2008. Available online at: https://www.legislation.gov.au/Details/C2008A00117

- Permit grants right to exploration and to inject on an appraisal basis
- Must have environment plan approved to undertake permit activities
- Must obtain approval from Minister before carrying out injection and storage on an appraisal basis
- Permits have a duration of six years but can be renewed for a further three years.

3. Declaration of an identified GHG storage formation
- Approval must be obtained before a GHG injection license is approved
- Eligibility determined on a range of factors including being suitable to store at least 100,000 tonnes of GHGs
- Minister must make the declaration if satisfied the formation is eligible

4. Application for a GHG holding lease
- If the application is currently not in position to inject, but will in the next 15 years they can apply for a GHG holding lease

5. Application for a GHG injection license
- Allows injections by licensee providing well is situated within the license area
- Injections must occur within five years
- GHG substance types and quantities cannot exceed those stated in the license

6. Site Closure
- Applications for a site closure certification can be made if a) injection operations have ceased, b) there is a ground for cancellation, c) the injection license is tied to a petroleum retention lease or production lease that has ceased to be in force
- Applications must include: a) written report on modelling of the behaviour of injected substance, b) written report on applicant's assessment of that behaviour, expected migration and short and long term consequences of migration c) applicant's suggestions to Commonwealth on the approach to monitoring after issuing a site closure certificate
- Once a site closure certificate is granted, the Minister can direct the operator to: a) remove all property, b) plug or close wells, c) provide conservation and protection of the natural resources in the area d) remediate any damage to seabed or subsoil e) reduce risks posed to navigation, fishing, pipeline operations, conservation or exploration and the enjoyment of locals
- Applications must be determined within five years by the Minister

At least 15 years following the issue of site closure certificate, the Minister can declare a closure assurance period. This provides the transfer of long-term liability to the Commonwealth. Prior to this, which may be at least 20 years from the site closure application, the injection licensee is liable to potential claims.

5.1.2 5.1.1 Development of Offshore Regulation

In 2011, the development of a set of further regulations as part of the existing Offshore Petroleum and Greenhouse Gas Storage (OPGGS) Act was finalised. This included the introduction of the Resource Management and Administration (RMA) Regulations in 2011, and the Gas Injection and Storage

Regulations in 2012. The main purpose of these regulations was to consolidate and streamline the existing regulations.

There are three main objectives to the RMA regulations.[47]

1. Ensure offshore operations are carried out to best practice and are compatible with maximising long-term petroleum recovery

[47] UCL Carbon Capture Legal Programme (2018) Offshore CO2 Storage Australia. Available online at: http://www.ucl.ac.uk/cclp/ccsoffnational-AUS.php

2. Administrators of the OPGGS Act are informed in a timely manner regarding exploration, discovery, development, production and injection activities

3. Provide framework for management of petroleum and GHG data

The Injection and Storage regulations details further requirements for six activities relating to injection and storage.[48]

1. Significant risk of a significant adverse impact (SRSAI) test: This requires the probability of the occurrence of an event multiplied by the cost that would be incurred

2. Declaration of storage formation: Requirement of information to determine if formation is suitable for permanent storage

3. Site plan: Includes predictions of the behaviour of the GHG substance, risk assessment, monitoring activities. This will be made publically available and any public comments received must be considered by the Minister

4. Incident reporting: Reportable incidents are any which vary from the behaviour prediction in the site plan and any leakage for any wells. The Minister then may require revision to the site plan to address these incidents

5. Decommissioning: Provisional decommissioning plan submission when applying for injection license. A final plan is required at least 12 months prior to ceasing injection

6. Discharge of securities: Regulations allow financial securities to be discharged when the Minister is satisfied the obligation for which the security was paid have been satisfied.

5.2 VICTORIA REGULATIONS

The State of Victoria developed onshore and offshore regulations for CCS storage in 2008 and 2010 respectively, the latter of which came into force in January 2012.

Both Acts require the Crown to grant a right to explore or inject and store greenhouse gases. The offshore regulation largely mirrors the national offshore legislation in order to avoid transboundary issues, as the Victoria offshore regulations only covers the first three nautical miles before defaulting to national regulations. In addition, both acts enable the surrender of an injection license, for which the Crown then becomes the owner of any injected substance. However, no insurance of long-term liability is offered, therefore the operator could remain liable after surrendering the site.

In 2013, Victoria produced a Carbon Capture and Storage Regulatory Test Toolkit,[49] to evaluate the Act's ability to regulate a commercial-scale CCS project. This work was undertaken as a collaboration between the Victorian State Government, Federal Government and the Global CCS Institute. A hypothetical project was assessed including mock approvals and permits. The conclusion of the exercise was that the Victorian legal and regulatory regime was fit for purpose. However, some opportunities to streamline the framework were identified. These include:

- Identify options for enabling cross-jurisdictional storage for carbon dioxide
- Consider international approaches to storage performance and assess relevance to Australia, including performance monitoring as a means to verify integrity.
- Consider need to align approach to long term storage liability across jurisdictions taking into account international developments.

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[48] UCL Carbon Capture Legal Programme (2018) Offshore CO2 Storage Australia. Available online at: http://www.ucl.ac.uk/cclp/ccsoffnational-AUS.php

[49] AECOM (2013) Carbon Capture and Storage Regulatory Test Toolkit for Victoria, Australia. Available online at: https://hub.globalccsinstitute.com/sites/default/files/publications/154238/carbon-capture-storage-regulatory-test-toolkit-victoria-australia.pdf

5.3 QUEENSLAND AND SOUTH AUSTRALIA

In 2009, the state of Queensland passed a regulatory framework for onshore injection and storage of greenhouse gases. This is a stand-alone act. The South Australian State Government made amendments to its legislation in 2009. Under that State's Petroleum and Geothermal Energy Act 2000, gas storage exploration licences, gas storage retention licences and gas storage licences now provide the necessary system to regulate CCS activities onshore within South Australia. Similar to Victoria, licenses in Queensland and South Australia can be transferred back to the state, but no transfer of long-term liability is offered.

5.4 WESTERN AUSTRALIA

In 2003, Western Australia adopted project-specific legislation to support the deployment of the Gorgon Joint Venture LNG project, resulting in the Barrow Island Act 2003, solely regulating carbon dioxide disposal as part of the Gorgon project. Since then state legislation has been proposed, but it was not enacted and it did not pass through parliament.

5.5 GAP ANALYSIS AND SUMMARY - AUSTRALIA

The GCCSI indicator ranks Australia as the highest country in its assessment, with a "sophisticated and largely consistent approach to CCS at both the Commonwealth and state levels". However, the report states there have been no noticeable changes to either regimes since 2015. The GCCSI comment there are gaps and obstacles such as long-term liability and indemnification, which varies between states. The Australian federal regulations allow full indemnity, with liability being passed to the Commonwealth once the Minister has declared a closure assurance period, which must be at least 15 years after the site closure. State regulations do not have this assurance for operators, with liability still remaining with the project operators even after surrendering their license.

Another discrepancy between the regulations is that Australian states have approached their CCS regulations differently. Some regulations are stand alone, others are project specific, or they could be amendments to other legislation such as petroleum regulations. It is difficult to anticipate the extent to which this may cause problems.

To date, the various CCS regulations remain fairly new and untested, and interviewees have commented that there are opportunities to streamline the regulations, with communications between government departments. Overall though, the regulations are considered by GCCSI to be fit for purpose.

6. JAPAN

Japan has a long-standing regime relating to CO_2 storage, since the 2007 amendment to the Marine Pollution Prevention Act was passed by the Ministry of the Environment[50]. This was originally for the purpose of deep ocean injection, but this is now being used instead by Japan to develop CCS projects. It states operators must:

- Obtain a CO_2 disposal permit from minister of the environment
- Conduct marine EIA before submission of permit application
- Monitor status of pollution at the storage site

In addition the following documents are required as part of the permit application process:

- Project plan
- Monitoring plan
- Site selection report
- EIA report
- Document to present financial capability
- Document to present technical capability

As part of the permitting process presumably for offshore CO_2 injection and storage, there are three grades or phases of marine environmental survey which must be undertaken. These are:

1. Regular marine environmental survey – undertaken seasonally
2. Precautionary marine environmental survey – monitors whether a potential negative effect to the main environment could occur
3. Contingency marine environmental survey – continuous monitoring until no negative effect to the marine environment is caused by CO_2 streams.

During the monitoring plan required as part of the permit, the threshold for each monitoring phase transition must be set. If CO_2 leakage exceeds the lowest threshold, CO_2 injection must be stopped. At this point, the second phase of survey commences. If this threshold is exceeded, the final continuous monitoring is initiated. These monitoring results must be reported to the Ministry of the Environment.[51]

Since then, CCS is referred to in Japan's Energy Plan, published in 2014, aiming to promote research and development for practical use of CCS around 2020[52]

The GCCSI Legal and Regulatory Indicator comments that despite Japan developing demonstration and large-scale facilities for CCS, complementary CCS legal and regulatory models have not been produced. The current Japanese regulations are aligned to the London Protocol, but there are several gaps such as no provisions for long term liability. There are many areas where the CCS regulations could be developed in the future.

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[50] Research Institute of Innovative Technology for the Earth (2017) Japanese R&D Strategy and Direction on CO2 Storage. Available online at: http://www.koreaccs.or.kr/esub03_7_2/data/down/year/2017/type1/LECTURE/id/1255/num/2

[51] Japan CCS Co. (2017) Tomakomai CCs Project. Available online at: https://ieaghg.org/docs/11mon/Session6_Talk1_IEA-GHG_Network%20Meeting_DaijiTanase_JCCS.pdf

[52] Ministry of Economy, Trade and Industry, Japan (2016) Present Statues and Future Challenges of CCS in Japan. Available online at: http://www.ghgt.info/images/GHGT13/2_Takuro_Presentation.pdf

7. INDONESIA

Indonesia has no specific regulations or a legal framework which governs CCS projects. Research by the Asian Development Bank (ADB) in 2013 recommended that regulations be developed at the same time as implementing a CCS pilot project[53]. There are various other regulatory frameworks in place, covering surface and subsurface rights, environmental concerns including air and water, and impact assessments. These could be adapted for CCS. However, in addition to existing regulations, the CCS regulations would also need to cover health and safety, liability, CO_2 transport. In addition, the ADB report recommends developing a public engagement process with the pilot project, and inviting participation from key stakeholders including local residents when assessing potential pilot projects.

The ADB report outlines the regulations necessary to support commercial development of CCS and the current regulations in Indonesia. A simplified version of this is shown in Table 7.1. Indonesia has a wide range of regulations which can be adapted for CCS but many new concepts will need to be introduced to update the regulatory framework such as laws for accessing pore space, liability and environmental protection.

Table 7.1 Requirements for a Regulatory Framework for CCS per the ADB

Issue	Current Status	Required for CCS
Classification of CO_2	No legal definition of CO_2 currently exists. Oil and gas operators required to maintain CO_2 inventory	Environmental protection laws and water regulations defining “waste” and “pollution” which could be used to classify CO_2.
Subsurface and surface rights for CO_2 transport and storage	No laws for ownership, grant, or lease of surface or subsurface pore space for CCS currently exist. Only the government has power to grant mineral rights. Several types of land ownership rights are defined but typically duration of rights may be too short for CCS	CCS will require long-term access through ownership, grant, lease, or contract to surface and subsurface rights, including access to pore space for storage.
Legal liability	No current framework exists for CCS. Liability defined through environmental regulations affecting upstream oil and gas productions	Short-term liability relates to operations and long-term liability could relate to environmental and health risks from leakage, contamination, or migration. Liability for CCS can be addressed by adapting existing liability rules for minerals.
Environmental Protection	No environmental protection rules in place for CO_2 capture, transport, injection or storage	Could adapt the existing laws on Environmental Protection and Management (2009), Water Resources, Environmental Impact Assessment
CO_2 transport	No regulator for CO_2 transport. Upstream pipelines under jurisdiction of Oil and Gas standard	Clear regulatory and legal framework defining who can build, own, and operate pipelines used to transport CO_2 for CCS
Health and Safety	Standards relating to oil and gas are available, but none specific to CCS. Also regulations for oil and gas distribution pipelines could be adapted to CO_2 transport	A clear definition of health and safety for workers and of operations in CCS will be required, some of which will be adapted from existing rules.

[53] Asian Development Bank (2013) Prospects for Carbon Capture and Storage in Southeast Asia. Available online at: https://www.adb.org/sites/default/files/publication/31122/carbon-capture-storage-southeast-asia.pdf

Issue	Current Status	Required for CCS
EOR	Limited regulations exist. Oil and gas exploration and production regulations exist	A clear approach to how CO_2-EOR will be integrated into the production-sharing arrangement and built into oil-gas field development programs
Foreign direct investment for CCS	Some controls on foreign investment in mineral exploration and productions. Foreign direct investment is regulated, given foreign-owned companies 30 years to operate, but can be extended by another 60 years	A clear investment climate that supports foreign direct investment will be necessary for raising international funding for commercial-scale CCS projects

Currently, planning is underway for the first CCS project in South East Asia[54]. The Gundhi project based in Central Java, Indonesia is expect to inject 30 tonnes CO_2 a day, a total of over 20,000 tonnes across two years. It is being funded by the Asian Development Bank, with construction expected to begin in 2019. At present, the project is being run under existing oil and gas regulations, there has been no clear development of CCS regulations.

[54] Global Landscapes Forum (2018) Gundih Carbon Capture and Storage Pilot Project: Current Status of the CCS Project in South and Southeast Asian Regions. Available online at: https://www.globallandscapesforum.org/presentation/gundih-carbon-capture-and-storage-pilot-project-current-status-of-the-ccs-project-in-south-and-southeast-asian-regions/

8. WIDER REGULATIONS

8.1 LONDON PROTOCOL

The London Convention is a global agreement for regulating dumping of waste at sea, consisting of 87 countries. The London Protocol is an updated and more detailed version of the Convention with 45 contracting parties. In 2006 amendments to the 1996 London Protocol were adopted. These amendments allow and regulate the storage of CO_2 streams from CO_2 capture processes in geological formations under the seabed[55]

The issues for CCS in relation to the London Protocol is the transboundary export of CO_2 for sub-seabed geological storage. The protocol states in article six that "Contracting Parties shall not allow the export of wastes or other matter to other countries for dumping or incineration at sea". This prevents countries exporting CO_2 to another country in the circumstance that they do not have sufficient storage for CO_2. In 2009 an amendment to remove this restriction was adopted. Unfortunately, export of CO_2 for the purpose of offshore 'disposal' in a CCS storage site is still prohibited as the amendment requires two-thirds of parties to ratify before it comes into force. As of 9th February 2016, the International Maritime Organisation (IMO) concluded three parties have ratified the amendment[56] but this is now believed to have increased to five.

8.2 OSPAR CONVENTION

The OSPAR convention is The Convention for the Protection of the Marine Environment of the North-East Atlantic, with 15 nations and the European Commission as contracting parties. It is named after the Ministerial Meeting of the Oslo and Paris Commissions that was held in 1992, where the convention was initially open for signature. In 2007, the OSPAR Convention adopted amendments to the annexes of the convention to allow the storage of CO_2 in geological formations under the seabed. It ensures environmentally safe storage of CO_2 streams in geological formations including OSPAR Guidelines for Risk Assessment and Management of that activity. In addition, a decision was taken to prohibit CO_2 placement into the water-column of the sea and on the seabed, because of the potential negative effects[57]

8.3 ISO STANDARDS

In 2011, ISO/TC 265 for carbon dioxide capture, transportation and geological storage was created. The scope is:

> *"Standardization of design, construction, operation, environmental planning and management, risk management, quantification, monitoring and verification, and related activities in the field of carbon dioxide capture, transportation, and geological storage (CCS)."*

This technical committee is made up of 20 participating members and ten observing members listed in Table 8.1. Participating members influence the standard development and strategy by participating and voting in technical and policy meetings. These members sell and adopt ISO standards nationally. Observer members attend meetings but do not vote or influence. They can sell and adopt the ISO standards nationally. ISO standards are voluntary, but those that choose to conform must be able to prove they are compliant.

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55 Dixon, T., Mc Coy, S., and Havercroft I. (2015) Legal and Regulatory Developments on CCS. Available online at: https://www.sciencedirect.com/science/article/abs/pii/S1750583615001875

56 International Maritime Organisation (2016) List of amendments to the London Protocol. Available online at: http://www.imo.org/en/ourwork/environment/lclp/documents/list%20of%20amendments%20to%20the%20london%20protocol.pdf

57 Dixon, T., Mc Coy, S., and Havercroft I. (2015) Legal and Regulatory Developments on CCS. Available online at: https://www.sciencedirect.com/science/article/abs/pii/S1750583615001875

The secretariat is the Standard Council of Canada, with the Standardisation Administration of China as the twinned secretariat. The Secretariat runs and coordinates the technical committee

Table 8.1 Members of ISO/TC 265

Participating members	Observing members
Australia	Argentina
Canada	Czech Republic
China	Egypt
France	Finland
Germany	Iran, Islamic Republic of
India	New Zealand
Italy	Qatar
Japan	Serbia
Korea, Republic of	Sri Lanka
Luxembourg	Sweden
Malaysia	
Mexico	
Netherlands	
Norway	
Portugal	
Saudi Arabia	
South Africa	
Spain	
United Kingdom	
United States	

In addition to national members, there are a range of organisations in liaison with the technical committee. These are:

- The European Network of Excellence on the Geological Storage of CO_2 (CO_2GeoNet)
- Carbon Sequestration Leadership Forum
- European Industrial Gases Association
- Global CCS Institute
- International Energy Agency
- World Resources Institute

8.3.1 Background and Structure of ISO Standards

For a new technical committee to be set up and approved, a proposal must go forward to the ISO boards. Countries vote on whether they feel there is a need for standards in that field, and if enough votes are received, a new technical committee is formed.

Table 8.2 Status of ISO Standards relating to CCS[58]

Code	Document type	Title	Stage Code	Stage Description[59]
ISO/TR 27912:2016	Technical Report	Carbon dioxide capture -- Carbon dioxide capture systems, technologies and processes	60.60	International Standard published
ISO 27913:2016	Standard	Carbon dioxide capture, transportation and geological storage -- Pipeline transportation systems		
ISO 27914:2017	Standard	Carbon dioxide capture, transportation and geological storage -- Geological storage		
ISO TR: 27915:2017	Technical Report	Carbon dioxide capture, transportation and geological storage -- Quantification and verification		
ISO 27917:2017	Standard	Carbon dioxide capture, transportation and geological storage -- Vocabulary -- Cross cutting terms		
ISO/TR 27918:2018	Technical Report	Lifecycle risk management for integrated CCS projects		
ISO 27919-1:2018	Standard	Carbon dioxide capture -- Part 1: Performance evaluation methods for post-combustion CO_2 capture integrated with a power plant		
ISO 27916	Standard	Carbon dioxide capture, transportation and geological storage -- Carbon dioxide storage using enhanced oil recovery (CO_2-EOR)		
ISO/CD 27920	Committee Draft	Carbon dioxide capture, transportation and geological storage (CCS) -- Quantification and Verification	30.99	Committee Draft approved for registration as draft international standard
ISO/CD 27919-2	Committee Draft	Carbon dioxide capture -- Part 2: Evaluation procedure to assure and maintain stable performance of post-combustion CO_2 capture plant integrated with a power plant	30.20	Committee Draft study/ballot initiated
ISO/DTR 27921	Draft Technical Report	Carbon dioxide capture, transport and storage -- CO_2 stream composition		
ISO/AWI TS 27924	Approved Work Item Technical Report	Lifecycle risk management for integrated CCS projects	20.00	New project registered in TC/SC work programme

58 Correct as of 1st February 2019

59 Details of the different stages an ISO standard goes through can be found at https://www.iso.org/stage-codes.html#30.20

8.3.2 Role of ISO Standards

The technical committee do not release a statement about their reasoning for producing the standards, which is the same for all ISO committees. Different countries will have different reasons for why they think these standards are important and needed. A range of different people involved in the ISO standards and different countries' committees have been interviewed to discuss what they believe the role of the ISO standards are. One interviewee felt that the ISO standards would be a good framework for countries which do not currently have CCS regulations, when they begin to develop their own. Another interviewee believed when CCS deployment accelerates, they suspect there will be a sudden flurry of builds, so they will need standards to rely upon which is where the ISO standards have a role. The interviewee admitted the standards might not be perfect, but would be sufficient to help projects get going as there will likely be a shortfall of experts, whereas a range of international experts will have contributed to the ISO standards. Finally, another interviewee said their country's view was that technical reports were useful but they would prefer to hold off on developing the formal standards. This is due to there being a lack of projects to date, so not all the issues have been resolved and knowledge is still developing. They also commented on the difficulty making changes to the standards at a later date once they have been published. However, this country is still a participating member of the technical committee, as they would still prefer to have an input on the standards than not be involved.

8.3.3 Content of ISO Standards

The content of ISO standards is produced my participating members in the technical committee, for example an interviewee confirmed Japan has had a strong input in the capture standards. An interviewee explained the process of producing the standards is quite slow and methodical, but is a well audited process, lasting on average three years. With members across a range of time zones, this can slow progress, so plenaries are held to get participants together.

When deciding the specific content, such as monitoring timescales, a consensus approach is taken across participating members. An interviewee commented this will not necessarily be unanimous decision. Overall it is a diplomatic process, and it is not simply a case of going with the lowest common denominator, and a consensus process buffers the impact of an outlier opinions.

As the ISO standards are not a legal regulation, the content of the various standards has not been assessed in detail.

8.4 GAP ANALYSIS AND SUMMARY

Overall there are a number of different standards or protocols in place which are not part of national legislation, but could impact the regulatory frameworks of a wide range of countries. Unfortunately the amendment to allow the export of CO_2 for storage to other countries still has not been ratified, which could be a considerable barrier, especially in the EU, where some member states do not have suitable sites for storage. The role of the ISO standards is advisory, since they are not binding government requirements, but they have the potential to be useful in a number of different situations, such as informal guidelines for CCS project developers to follow in countries that are still developing their own government regulatory frameworks for CCS.

9. ANALYSIS

9.1 GCCSI LEGAL AND REGULATORY INDICATOR

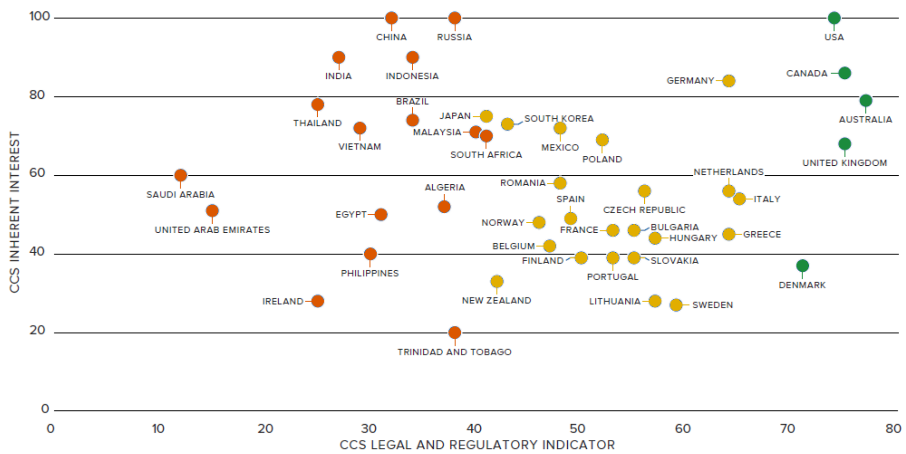
In 2018, the GCCSI published their second edition of their CCS Legal and Regulatory Indicator (CCS-LRI)[60] The indicator assesses the legal and regulatory frameworks of 55 countries, focusing on a wide range of administrative and permitting arrangements throughout the project lifecycle in addition to evaluating issues relating to environmental assessments, public consultation and long-term liability.

Since the last publication of the GCCSI legal and regulatory indicator in 2015, 11 countries have introduced new legislation or made legislative amendments related to CCS, but only seven of those countries have had a change in their GCCSI rating score, out of the 55 countries included in the assessment. The top five countries for CCS regulation are Australia, Canada, Denmark, the UK and the USA, referred to as Band A. The GCCSI states that legal and regulatory models in these countries are “sophisticated and address novel aspects of the CCS process”, although the results show these nations have seen little to no change since the 2015 publication. The GCCSI speculates these delays could be due to the absence of commercial-scale projects, resulting in governments delaying further legal and regulatory development. Those in Band B and C are countries with limited or very few CCS specific laws. The ranking of countries in the legal and regulatory indicator are shown in Figure 9.1.

In addition the indicator comments on countries such as China, Japan and Korea which have had demonstration and large-scale facilities developed in recent years, have not complemented this with the production of CCS specific legal and regulatory models.

Overall the report concludes there have been little to no material change in the status of CCS legal and regulatory models in many countries worldwide between 2015 and 2018. In addition, it raises the important point that legal or regulatory frameworks which fail may lead to project delays or reduce confidence in CCS.

Figure 9.1 GCCSI Legal and Regulatory Indicator



Adapted from the GCCSI LRI, Band A= Green, Band B=Yellow, Band C= Orange

60 Global CCS Institute (2018) CCS Legal and Regulatory Indicator (CCS-LRI). Available online at: http://decarboni.se/sites/default/files/publications/202111/ccs-legal-and-regulatory-indicatorglobal-ccs-institute-2018digital.pdf

9.2 KEY FINDINGS FROM INTERVIEWS

Some key themes were identified from the interviews conducted for this study (see list of those interviewed in the Appendix).

In relation to the overall advancement of the CCS regulatory environment there was a split between responses as to whether it was sufficiently advanced. One interviewee commented that since projects were being permitted, this meant it was sufficiently advanced. They noted that although many people during consultations for the development of regulations will list many requirements they believe are necessary, there is a differentiation between what is needed and what is nice to have in a regulation.

In contrast, other interviewees stated they believe that some key barriers remain including the inadequate clarity and support around ownership of pore space. Some interviewees felt some regulations were too detailed or too prescriptive. The majority of interviewees considered current tax credits to be insufficient; one interviewee suggested implementing an investment tax credit in order to further research and development.

When discussing the key barriers, the main issue raised by interviewees was a lack of experience by regulators - a barrier that was also recognised by regulators themselves. As there have been a limited number of projects to date, agencies are fairly inexperienced implementing the regulations, so it can be a long process. In addition, identifying gaps or issues in regulations is difficult until enough projects have tested the regulations. This is the reason for the regulatory test toolkit undertaken in Victoria using a hypothetical project.

Another issue raised by the majority of interviewees related to price and incentives. At the moment, there is a large requirement for sufficient time and money to get a permit application completed and approved, in addition to installing and paying for CCS technology.

Interviewees suggested that if the incentives are not sufficient, then it is perceived to be more expensive to do CCS than not, so it is unlikely a company will choose to do CCS. It was acknowledged that steps to address this are being taken such as the 45Q, EU ETS Innovation Fund and the CA LCFS.

In addition, one interviewee commented that once incentive prices are right it makes other issues disappear, in the sense of them being less material to the operator if the financial incentive is there.

Despite comments on liability being raised as a gap or an area which varies between regulations, it was never raised in the interviews as something which is a barrier to projects, i.e. no projects were seen to have failed due to lawsuits or liability costs.

When discussing next steps for the CCS regulatory landscape during the series of interviews undertaken for this report with CCS experts, the following suggestions were put forward by the interviewees.[61]

- Incentives such as 45Q are not attractive enough; more money is required to incentivise CCS projects over a longer time horizon
- Projects need subsidising so pilots can be successful and build momentum, so future projects and regulatory agencies can learn from pilot projects.
- More practicality relating to regulations such as 50-year default opposed to 100 years, or more flexibility – it should be acknowledged this was not the view of all interviewees, with one commenting legal flexibility can make industry nervous since they prefer certainty
- Streamlining the regulations while finding the balance between acceptability, protection and project liability.

[61] See the Appendix for full list of interviewees

- There is a role for governments to push CCS; for example, a role for avoided emissions from CCS to be expressly included in national GHG inventories

9.3 DETAILED COMPARISON BETWEEN KEY REGULATIONS

In the introduction, a range of key regulatory issues were outlined. These have been compared in detail across five different regulatory frameworks:

- EPA UIC Class VI Well Permits
- CA LCFS
- Alberta CCS RFA recommendations
- EU CCS Directive
- Australian Offshore Petroleum Amendment

The comparison of these regulations can be found in Table 9.1. Each of these regulatory issues is discussed and compared in detail below.

Post-Injection Site Care (PISC) and Site Closure

The period for post-injection site care varies from a maximum of 100 years monitoring for the CA LCFS to a minimum of 15 years in the Australian Offshore Petroleum Amendment. Monitoring will continue in EU member states following transfer of liability, but this will be to a lesser extent. This is certainly a key area where there is disparity between regulations, at the same time that there is also flexibility in some regulations on the length of PISC. The extent to which the variation in PISC regulations may be a barrier to CCS project viability depends on the overall context of each regulatory regime. Project developers who operate globally will certainly need to take into account that such wide variations in the CCS regulatory regimes do exist.

Financial Requirements

Mandatory regulations such as the EU CCS or the EPA UIC Class VI regulations require proof of financial resources to cover any obligations relating to corrective measures or leakages. Proof of financial ability to cover potential liabilities is fairly standard across various CCS regulations, except the CA LCFS, where this is considered out of scope because CCS project operators apply for CA LCFS credits as a financial incentive rather than regulatory compliance.

Long Term Liability

There is considerable disparity between regulations in relation to long term liability. For the US EPA UIC Class VI well permits, site closure does not eliminate responsibility or liability and the EPA cannot transfer this liability between entities. For the CA LCFS the operator is liable for leakage for the first 50 years (to buy credits to offset leakage), after which any liability is paid from the CA LCFS buffer pool of credits instead.

Liability is transferred to the state authority after at least 20 years after site closure in the EU CCS Directive, unless there are concerns over permanence of the CO_2. Liability is also transferred back to the Commonwealth for the Australian Offshore Petroleum Amendment, the time at which this occurs depends on when a closure assurance period occurs, which is after at least 20 years. In summary, not all regulations allow a transfer of liability back to the state or relevant authority, and those which do have differing time frames for when this can occur.

Liability for Leakage and Environmental Damage

In most regulations there is a level of financial liability for environmental damage or leakage of CO_2. How this is paid depends if there is a credit system in place; for example, surrender of emission trading allowances for the EU CCS Directive. The Alberta RFA recommends creation of a post closure stewardship fund which all projects contribute to, which has a similar but separate role to the buffer pool which has been established in the CCS Protocol of the CA LCFS. The remaining regulations mainly require the operators to correct the physical damage and pay any fines.

Public Engagement

In general, the regulators all make aims to be transparent and engage the public and other key stakeholders. The US EPA is required to respond to comments made on UIC Class VI permit applications; applicants must respond to comments on applications to qualify for the CA LCFS; and the Commonwealth Minister will consider comments made from applications in Australia. In the EU CCS Directive, provisions must be put into place in member states to engage the public, in addition to public access to the EU Commission's reviews of all CCS permit applications within member states.

Thresholds

Some regulations apply to only projects meeting certain requirements; for example, the EU CCS Directive and the Australian Offshore Petroleum Amendment do not apply to projects storing less than 100 kilotonnes of CO_2. The other regulations do not have any thresholds, all projects which are undertaking geologic storage of CO_2 must have a valid permit.

Monitoring and Reporting

Monitoring and reporting plans and requirements vary considerably between regulations. Most regulators require an annual report but others have more demanding requirements; for example, semi-annual reporting, and informing CARB every quarter of details relating to quantities of fuels sold for the CA LCFS. The monitoring requirements vary and the full details of these are not included in Table 9.2 due to their extensive nature. In general, most regulators require a monitoring or environmental plan to be submitted with the application which will include how the plume is monitored, what technologies are used, how this will be recorded and verified if appropriate, in addition to any other monitoring of the surface, water sources or subsurface with duration of the monitoring period varying between regulations.

Pore Space Access

Addressing concerns relating to accessing pore space is considered out of scope for both the EPA UIC Class VI well permits and the CA LCFS. This is because both programs see pore space access as the CCS project developers commercial responsibility; i.e., if there is no pore space access negotiated by the developer, then there is no CCS project for the US regulators to review.

The EU CCS Directive requires member states to ensure measures are taken to allow operators to obtain pore space access. In Australia, operators must apply for access to acreage through the Commonwealth Minister for offshore storage.

In many cases, access to pore space and duration of that access for specific projects may be seen by regulators to be a commercial siting issue for project developers governed by local laws for mineral or sub-surface rights, and not a permitting issue per se.

Flexibility

The CA LCFS CCS Protocol is a very prescriptive regulation. CARB said the philosophy for fixed regulatory requirement was rewarded with the high values of the LCFS credits, for tonnes of CO_2 emissions sequestered to those who comply, which are currently US$180-200/tonne. CARB felt that rewarding CCS project developers with this level of benefit is in line with regulations to ensure certainty for long-term underground retention of CO_2.

Many other regulations do allow some form of discretion in certain permit conditions by a senior regulator such as the EPA program director or the Commonwealth Minister depending on project-specific circumstances.

Other Variations

There are some other variations between regulations worth noting. In the USA, states can apply for primacy to regulate the UIC permits themselves rather than the EPA regional office, which could lead to inconsistency between implementation of the regulation between states, but could also streamline or speed up applications in some states compared to others.

In contrast, to maintain consistency in the EU CCS Directive, the EU Commission intends to review all CCS applications across all member states.

Finally, in line with the stringent nature of the CA LCFS regulations, operators must be verified every year in order to assure the CO_2 is being stored safely.

Table 9.1 Regulatory Comparison between Key Regulatory Frameworks

	PISC and Site Closure	Financial Requirements	Long Term Liability	Liability for Leakage and Environmental Damage	Public Engagement	Thresholds	Monitoring and Reporting	Pore Space Access	Flexibility	Other
UIC Class VI well permits	50 years PISC (director's discretion)	Financial responsibility must be demonstrated for corrective action, PISC, site closure, emergency and remedial response	Site closure does not eliminate any potential responsibility or liability of the owner or operator under other provisions of law. EPA does not have the authority to transfer liability from one entity to another.	Financially viable, which is why proof of available finance is required for more stages of the project (see financial requirements)	All comments disclosed and publically available. EPA are required to respond	No exclusions, if its geologic storage it needs a Class VI permit	Semi-annual report to authority with electronic report and record-keeping	Out of the scope of the EPA	Yes – Director's discretion	States can apply for Primacy
CA LCFS	100 years monitoring post site closure	N/A	50 years. Beyond 50 years post-injection, the project operator is no longer responsible to make up any credits found to be invalid due to leakage. The credits are taken from the buffer pool instead.	Credits for verified GHG emission reductions can be invalidated if sequestered CO_2 associated with them is released or otherwise leaked	Public have 10 calendar days to make comments on applications. Applicant has 30 days to respond.	No differentiation, all projects wanting to apply for the credits will be under the same level of scrutiny	Submit an annual report of sequestered CO_2, quarterly volumes of fuels delivered to California, and energy use and chemical data of the carbon capture and CO_2 injection facilities.	Out of scope of the CA LCFS	No	Must undergo verification annually

	PISC and Site Closure	Financial Requirements	Long Term Liability	Liability for Leakage and Environmental Damage	Public Engagement	Thresholds	Monitoring and Reporting	Pore Space Access	Flexibility	Other
Alberta CCS Regulatory Framework Assessment Recommendations	At least 10 years have passed since approval of final closure plan	Require operators to post financial security to pay for site closure and reclamation if they become defunct.	Transfer liability for CO_2 credits to the Crown when a closure certificate is issued. Transfer of most of the liabilities for a CCS project to the province once a closure certificate is issued.	Creation of a Post Closure Stewardship Fund to cover some liabilities with contributions to the fund coming from those projects injecting CO_2 under sequestration leases.	Ensure consultation requirements are appropriate for CCS, including the requirement that everyone within the tenure boundary be informed about a CCS project.	None	Require MMV and closure plans to be based on a project-specific risk assessment, and include the use of best available technologies to monitor the atmosphere, surface, ground and surface water, and subsurface	Clarify that CCS operators can apply for access to conduct MMV or reclamation activities over the entire area of their carbon sequestration lease.	Consider applications on a case-by-case basis, and give the regulator flexibility	

	PISC and Site Closure	Financial Requirements	Long Term Liability	Liability for Leakage and Environmental Damage	Public Engagement	Thresholds	Monitoring and Reporting	Pore Space Access	Flexibility	Other
EU CCS Directive	As set out in post-closure plan. Monitoring will continue on a lower level by competent authority following transfer of liability	Financial provision should be made in order to ensure that closure and post-closure obligations under this Directive to take corrective measures in case of leakages or significant irregularities, can be met.	Responsibility can be transferred to competent member state authority after a minimum of 20 years after site closure, as long as authorities are convinced all available evidence indicates that the stored CO_2 will be completely and permanently contained	Liability for climate damage as a result of leakages requires surrender of emissions trading allowances for any leaked emissions. Operator is obliged to take corrective measures in case of leakages on the basis of a corrective measures plan	The EU review of the permit will be made public.	If its research and development project and storing less than 100 kilotonnes, the directive does not apply	The operator should report the results of monitoring to the competent authority at least once a year.	Member States shall take measures to ensure potential users can obtain access to storage sites for the purposes of geological storage of the produced and captured CO_2	Flexibility when member states transpose legislation	All permit applications should be reviewed by the Commission, national authorities should consider comments when making their decision.

	PISC and Site Closure	Financial Requirements	Long Term Liability	Liability for Leakage and Environmental Damage	Public Engagement	Thresholds	Monitoring and Reporting	Pore Space Access	Flexibility	Other
Australian Offshore Petroleum Amendment	At least 15 years following the issue of site closure certificate, the Minister can declare a closure assurance period.	Must show financial resources in application.	When the Minister declares a closure assurance period, this provides the transfer of long-term liability to the Commonwealth	Financially liable.	Site plan will be made publically available and any comments received will be considered by the Minister	Storage of at least 100,000 tonnes of GHGs	Environmental plans must include arrangements for recording, monitoring and reporting information in relation to compliance with environmental standards and for periodic reporting to the Minister.	Must apply for access to acreage through the Commonwealth Minister	The Minister also has broad discretion to impose "whatever conditions appropriate"	

9.4 KEY REGULATORY DEVELOPMENTS – OVERVIEW

As part of this report, a wide range of different regulations and frameworks have been reviewed. In order to summarise the crucial developments in CCS regulations since the last CCP review, the key documentation reviewed in this report have been split into three groups, outlined in Table 9.2

Table 9.2 Key Examples of Documentation Reviewed in this Report

Mandatory Regulatory Frameworks	Incentives, Funding and Optional frameworks	Future Developments
■ EPA UIC Class VI Well Regulations ■ US GHGRP ■ EU CCS Directive ■ Australia Offshore Petroleum Amendment ■ London Protocol ■ OSPAR Convention	■ US 45Q ■ CA LCFS ■ EU ETS – Innovation Fund ■ EU Fuel Quality Directive ■ Pan-Canadian Framework On Clean Growth And Climate Change – (pending) ■ UK Clean Growth Strategy	■ US National GHG Inventory ■ BC LCFS ■ Canadian CFS ■ ISO standards

There are a range of mandatory regulations which are in place across the globe, three of which are compared in detail in Table 9.1. In addition, the London Protocol amendment to allow transboundary movement of CO_2 is still to be ratified, preventing the movement of CO_2 to another country for offshore underground storage, despite the legal framework having been in place since 2009. However, the amendment to allow sub-surface offshore storage of CO_2 was approved in 2006. The OSPAR convention mirrors the London Protocol, in the North Atlantic, allowing sub-surface offshore storage of CO_2 minus the transboundary issue.

More significant developments have been made recently in relation to incentives, funding and optional frameworks. The CA LCFS may be one of the most stringent and extensive regulatory frameworks for CCS, but CARB also offers the largest financial incentive for CCS available to date. The increase in the value of the 45Q tax is another positive development which may see an increase in CCS projects.

In Canada, although the pending carbon pollution tax program does not address avoided emissions from CCS directly, the tax may still incentivise low carbon technologies such as CCS. In Europe, the EU ETS has created the Innovation Fund which has put aside 450 million allowances for low-carbon technologies including carbon capture. In the UK more specifically the Clean Growth Strategy has renewed the country's ambition and commitment to CCS, including £100 million in investment.

Finally, there are many key developments expected to occur in the next few years. These consist of the inclusion of avoided emissions from CCS in the US National GHG inventory, update of the British Colombia LCFS to include CCS, the development of a Canadian Clean Fuel Standard at federal level and the publication of more standards from the ISO Technical Committee 265 on carbon capture and storage. In addition, in the USA, the National Petroleum Council has been requested by the US Secretary of Energy to undertake a study on CCUS and the potential pathways leading to CCUS deployment at scale, which will results in a "Roadmap for CCUS Implementation".

9.5 ANALYSIS OF THE OVERALL CCS REGULATORY LANDSCAPE

Where are the general consistencies in CO_2 storage regulatory approaches?

When comparing the details of CO_2 storage regulations, there are many areas with consistent approaches. Most regulations require some form of proof of financial resources for liability purposes, with operators all liable for leakage during the project lifetime, and expected to rectify this. In general, CCS regulations have a very transparent process for reviewing applications and publishing comments from stakeholders and responding to these. Many regulators commented this was a critical part of developing regulations and approving applications. Apart from the CA LCFS, most regulations include some level of flexibility and discretion in relation to aspects of the framework, for example not a fixed period for PISC, or monitoring plans being approved on a case-by-case basis.

Where are there greatest differences or inconsistencies in regulatory approaches? And what are the reasons for these disparities?

One of the key differences in the regulatory approaches is to PISC, with this varying from 15 to 100 years of monitoring. Another is the approach to long-term liability with some (but not all) regulations allowing transfer back to the state or regulator, but the time frame where this occurs does vary. The CA LCFS CCS Protocol probably entails the most extensive regulations, with the highest level of monitoring requirements. This is due to CARB wanting to ensure the success of the LCFS and not damage the reputation of CCS. In return for it fixed regulatory requirements, CARB representatives stated they are "willing to pay a premium"[62] price for emissions sequestered by CCS projects, via California LCFS credits that currently trade between $180-200 per t$CO_2$e. It is worth noting this price is market driven and does fluctuate. In July 2016 it dropped to $67 per t$CO_2$e, but recently it has had a higher value, with a low of $124 per t$CO_2$e in the last year, and a low of $171 per t$CO_2$e in the last 6 months[63].

Another difference is the value of incentives such as 45Q versus CA LCFS, but in general there has been an increase in funding recently, despite withdrawal of other funding mechanisms since the previous CCP regulatory review. Overall, this disparity in incentives could be due to countries or states having different priorities or being in different stages of developing their regulatory frameworks. For example, the EU Fuel Quality Directive included CCS as part of fuel pathways since 2009, in comparison to the CA LCFS which introduced this in 2018 and British Columbia and Canada which are still developing fuel quality standards and considering the basis for including CCS projects.

Where are there potential conflicts posed by regulatory requirements?

It is most likely conflicts will occur where operators are looking to introduce projects in the same region or country where states or member states have differing frameworks. One example would be in the USA, where the CA LCFS requirements are more stringent than those of the EPA UIC Class VI well regulations or where states with primacy differ in implementing regulations. However, the CA LCFS is an optional scheme offering an incentive, so this is not necessarily a conflict but a decision to be made by the operator if they are willing to address these issues. In the USA, the more likely conflict would come from states which have primacy having slight differences in regulations to the EPA. However, this is hard to determine at the moment, with only one state having primacy for Class VI, but any discrepancies are expected to be minor.

Another possible conflict could be in the EU, with differing legal and regulatory regimes available to support the implementation of the CCS Directive. However, no major conflicts have been identified to date and the final EU Commission review of applications should help to promote consistency.

Finally, another conflict is the difference in long-term liability across Australia. The federal regulations allow transfer of liability back to the state, but the state regulations do not allow this. Overall, there are differences in monitoring or well requirements, but these are usually between countries, and are only likely to become material as deployment grows. These disparities are also likely to be tested as more projects are approved and as the regulations get trialled by actual projects and the regulators gain experience.

[62] Compared to the value of incentives of the California cap and trade system

[63] Between March 2018 and February 2019 and September 2018 to February 2019 for the 12 and 6 month periods respectively

10. CONCLUSIONS

Overall, regulators are aiming to promote transparency and generally seem to be taking into account comments from key stakeholders when developing regulations. Although many of these regulations have yet to be rigorously tested due to a low level of deployment, reviews of regulations have been carried out using hypothetical projects (Victoria, Australia) or recommendations from technical panels (Alberta CCS).

Regulations which have been developed are not consistent across the globe, with key disparities relating in particular to long term liability and post-injection monitoring requirements. Despite this, there are some areas such as the need for proof of financial ability to cover potential liabilities and public engagement which on the whole are being approached in a similar way.

In general, there has been a growth in CCS policy confidence. This can be seen by the development of new regulatory frameworks, in particular incentives such as 45Q. This is also reflected in the growing ambition of certain countries such as the UK, who have created the CCS Council and CCUS Cost Challenge Taskforce to aim to make CCUS economically feasible.

The GCCSI legal and regulatory indicator[64] ranks only five countries as having legal and regulatory models which are sophisticated enough to address novel aspects of the CCS process, showing there is still a considerable amount of development required in many countries, such as Japan and Indonesia, as highlighted in this report.

[64] See section 9.1

APPENDIX A INTERVIEWEE DETAILS

As part of this project, representatives of the following organisations were interviewed and contacted:

- US EPA
- University of Edinburgh
- Battelle
- US Department of Energy
- Global CCS Institute
- University of Calgary
- Natural Resources Defense Council
- Ministry of Energy, Mines and Petroleum Resources
- British Standards Institution Technical Committee
- ISO Technical Committee 265
- California Air Resources Board
- Independent Consultants

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